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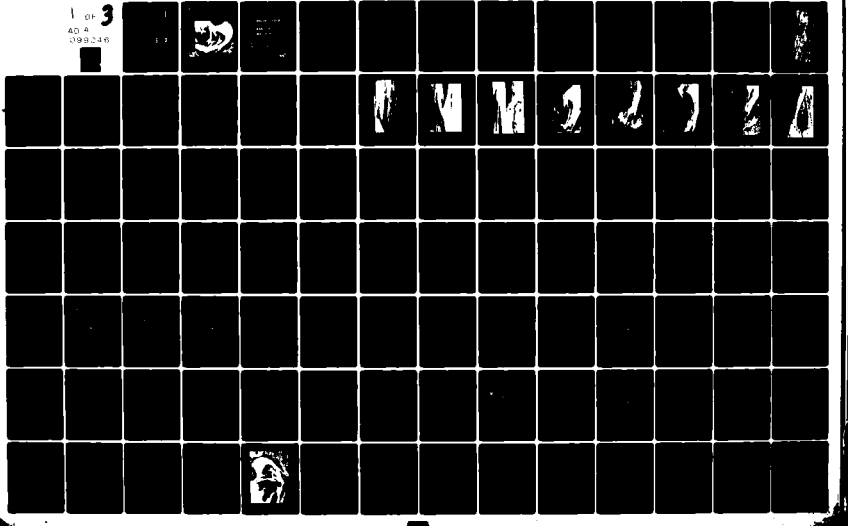

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Corps of Engineers, Waltham MA New England Div.

MADAKET HARBOR Nantucket Massachusetts Water Resources Improvement

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Feasibility Rept. July 77

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MADAKET HARBOR
NANTUCKET, MASSACHUSETTS
WATER RESOURCES IMPROVEMENT
FEASIBILITY REPORT

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

JULY 1977

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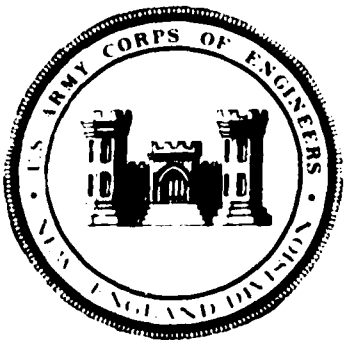
FEASIBILITY REPORT

MADAKET HARBOR

NANTUCKET, MASSACHUSETTS

WATER RESOURCES IMPROVEMENT

JULY 1977



Syllabus

The purpose of this study was to determine the economic, technical and environmental feasibility of instituting corrective measures at Madaket Harbor in the interest of flood control, hurricane protection, navigation and related purposes.

The major problems experienced are an extensive loss of shellfish resources and a severe reduction in the size and safety of the navigation channels and anchorages within the harbor. The cause of the problems was the breakthrough or breaching of the barrier beach which protected the harbor from the Atlantic Ocean. This occurred during Hurricane Esther on 21 September 1961, and the resultant breach has allowed natural forces to transport sand into the harbor and currents to constantly shift the sand. These conditions have caused the problems described above.

The study has reviewed and evaluated several approaches having the greatest potential to solve the problems and meet the needs in the Madaket Harbor area. The results of this evaluation indicate that closure of the Broad Creek breach with harbor dredging is the most feasible way to restore and preserve the natural assets of Madaket Harbor. This solution would require a reinforced sand barrier 3,000 feet long extending from Madaket to Esther Island and the dredging of approximately 650,000 cubic yards of sandy material from the harbor bottom. The estimated cost of this improvement is $6,730,000. With estimated annual benefits of $146,000 and annual charges of $728,000, the benefit/cost ratio would be 0.2 to 1.

In order for an improvement to be considered by the Federal government, a benefit to cost ratio must be greater than one.

It is therefore recommended that no water resources improvement project be adopted by the United States for Madaket Harobr, at this time.

MADAKET HARBOR

NANTUCKET, MASSACHUSETTS

FEASIBILITY REPORT

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THE STUDY AND REPORT

Nantucket Island, which is located in the Atlantic Ocean approximately sixteen miles south of the south shore of Cape Cod, Massachusetts is heavily dependent on the water resources of the ocean for its very existence. The island is comprised of approximately 30,114 acres of land much of which is made up of beach material, dunes and marshy areas. The major sources of employment on Nantucket are related to tourism and recreation, both fostered by the numerous water resource opportunities which are available on the island. The two island harbors of Nantucket and Madaket provide waterborne access to the island and are the centers of commercial and recreational finfish and shellfish activity on the island. Nantucket Harbor, on the north central coastal portion, is the major commercial center of the island and is the site of Nantucket Town. Madaket Harbor, the project site, is positioned at the western extremity of the island. On 20 September 1961 a violent northeast storm caused a breach in the barrier beach on the southern perimeter of Madaket Harbor. The breach, known as Broad Creek, subsequently continued to enlarge so that by 1974 it was approximately 1,200 feet wide and 20 feet deep. Sandy materials eroded from adjacent beaches were transported by local water currents into Madaket Harbor. This movement of sand has resulted in the overall deterioration of the water resources opportunities and activities in the Madaket Harbor area, i.e., navigation and shellfishing, and is therefore detrimental to the economic and social well-being of the entire island.

PURPOSE AND AUTHORITY

The purpose of this report is to determine the economic, technical and environmental feasibility of instituting corrective measures at Madaket Harbor in the interest of flood control, hurricane protection, navigation and related purposes.

Authority for conducting this study is contained in Section 219 of the Rivers and Harbors Act of 13 August 1968, (Title II, Public Law 90-483). This authority directed the Secretary of the Army acting through the Corps of Engineers to make a study of Madaket, Smith Point and Broad Creek, Massachusetts, in the interest of flood control, hurricane protection, navigation and related purposes.

SCOPE OF THE STUDY

This study comprehensively evaluated alternative measures to help alleviate the water resource problems at Madaket Harbor in order to recommend feasible solutions and evaluate the economic, environmental and social consequences of such measures. In the process of developing the various alternatives during the course of the study it was necessary to conduct field research and analyze the existing physical conditions in the harbor, review previous reports and available recorded data, conduct interviews with residents of the island and project future conditions with and without an improvement project. All plans were evaluated in the depth and detail needed to determine their feasibility in meeting the required objectives of the study.

STUDY PARTICIPANTS AND COORDINATION

A feasibility study such as this one for Madaket Harbor dealing with an evaluation of the advisability of a water resources improvement project requires close coordination between the Corps of Engineers, Federal, State and local interests, private industry, businesses, associations and individuals.

Soon after the breach occurred in 1961 and the harbor began to deteriorate, the local community began to realize the adverse economic, social and environmental impact the breachway would impose on the area. As a result of this realization a group of

island residents were appointed by the selectmen to what was called the Broad Creek Committee whose function was to study the situation and recommend a course of action. As a result of the committee activities and the efforts of other concerned residents and their Congressional delegation, Congress authorized the study in 1968. The Broad Creek Committee has been of invaluable assistance during the course of the study.

Coordination was initiated by holding a public meeting on 27 June 1970 at Nantucket. The needs and desires of local interests expressed at this initial meeting formed the basis of workshop meetings conducted during the course of the study with Federal, State, local and private interests. The findings of the study were presented to the local interests at a final meeting on 24 February 1976 at Nantucket. Appendix 5 contains pertinent correspondence exchanged among study participants during the course of the study.

THE REPORT

This report is a feasibility report organized into a main report and five appendices.

The main report is a nontechnical summation of the problems, needs and effects associated with improving Madaket Harbor by closing the breachway and dredging a portion of the harbor. It presents a broad view of the overall study for the benefit of general and technical readers. Included are a description of the study area and the present status of the harbor area, the needs for closure of the breachway and the problems connected with selecting a suitable plan and its effects, and a summary of the project economics indicating the benefit and the costs.

Appendix 1 is a detailed technical report following the same general outline as the main report and containing maps, photos, tables and charts pertaining to the study.

Appendix 2 is an environmental effects assessment based on the selected plan described in the main report. It examines the environmental setting without the project, the impact of the proposed action, adverse impacts which cannot be avoided, alternatives to the selected plan, relationships between local short-term uses of the environment and enhancement of long-term productivity, as well as irreversible commitments of resources.

Appendix 3 is a marine biology report which describes the present shellfish condition in Madaket Harbor and the technical and economic effects which may result from harbor improvement by dredging.

Appendix 4 is a social effects assessment which discusses the social effects and segments of the economic effects of the selected plan. It includes the collection of background information regarding the social effects of the proposed project, interviews with the local population from 4 June 1974 through 7 June 1974, and an interpretive summary of this pertinent information.

Appendix 5 contains pertinent correspondence between various study participants, including reports of other agencies.

PRIOR STUDIES AND REPORTS

There have been no prior Federal studies of the Madaket Harbor area in the interest of flood control, hurricane protection, navigation and related purposes.

A report dated 24 June 1970 was prepared by the Broad Creek Committee. The report recommended closure of the breach and restoration of the harbor for the commercial, recreational and boating benefits which would be derived by the island of Nantucket.

On 20 June 1973 the Tibbetts Engineering Corporation, under contract to the New England Division of the Corps of Engineers, completed a feasibility study to determine whether construction of a barrier system could be accomplished under conditions then existing in the harbor. This report concluded that a reinforced sand barrier using dredged sand material from the harbor and having a steel sheet pile core was best.

A second report entitled "Feasibility Report, Madaket Harbor, Nantucket, Massachusetts, Water Resources Improvement Study" was also prepared by the Tibbetts Engineering Corporation under contract to the New England Division of the Corps of Engineers. This second report was completed early in 1975 and developed costs, benefits, assessment of impacts, annual charges and descriptions of the problems and solutions. The information from this second report has been included in the appendices mentioned above.

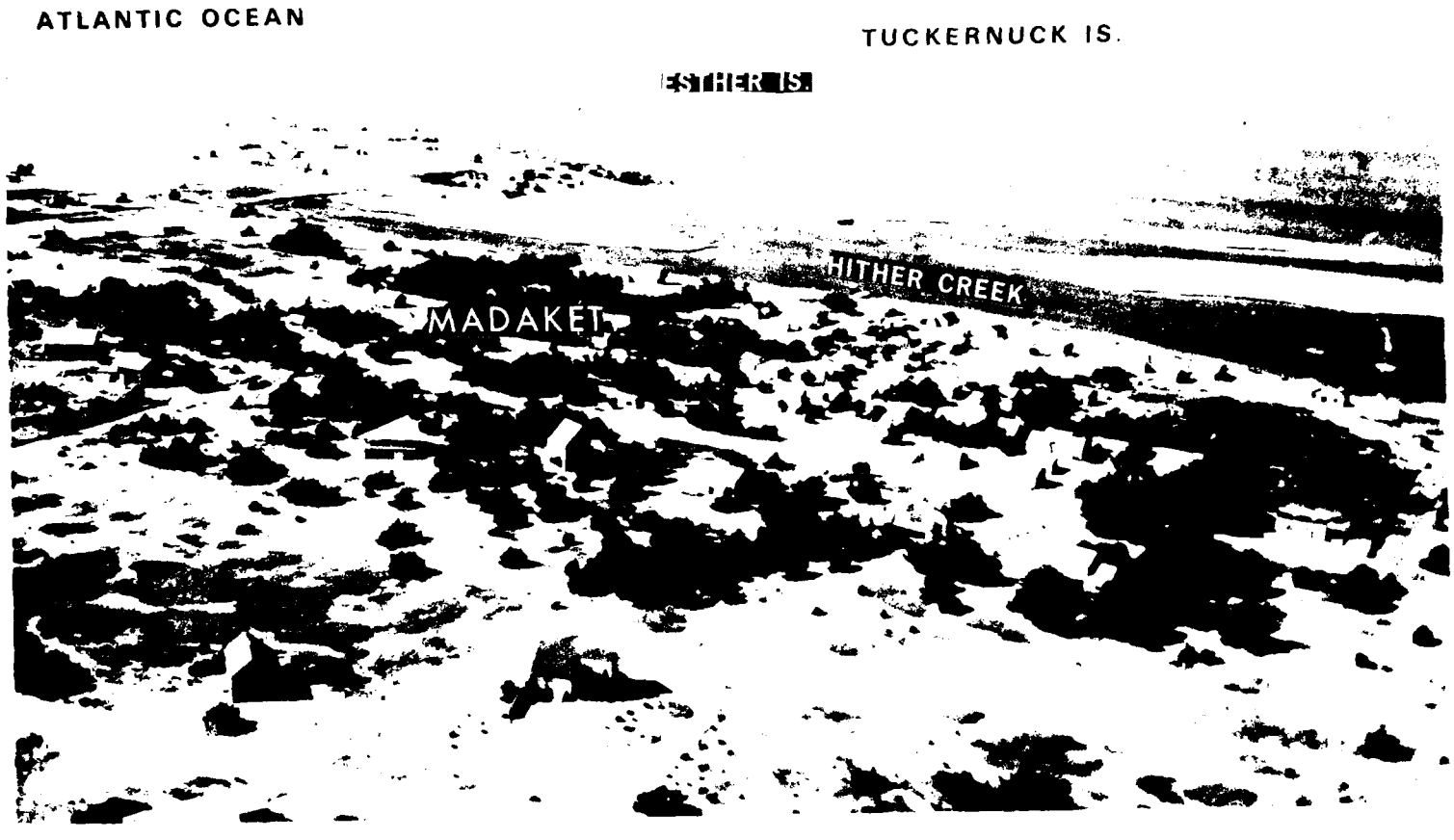
The shellfish resource benefits contained in the second report by Tibbetts Engineering Corporation were reviewed by several agencies including the Corps of Engineers, U.S. Fish and Wildlife Service, National Marine Fisheries Service and Massachusetts Division of Marine Resources. During 1975, these agencies coordinated their efforts to develop a benefits analysis. The final results of this analysis was submitted to the Corps by the Fish and Wildlife Service in December 1975. A summary of this analysis and other reports is contained in Appendix 5.

RESOURCES AND ECONOMY OF THE STUDY AREA

Individual native resources have a greater impact on economic well-being and growth potential of an island than on a comparable mainland community. The following pages will provide an understanding of the environmental and human resources of Madaket Harbor and its development, economy and future in relation to Nantucket Island.

ENVIRONMENTAL SETTING AND NATURAL RESOURCES

Madaket Harbor, the second largest harbor on Nantucket Island, has an area of 746 acres. Located at the western extremity of Nantucket, it is bounded on the north by Eel Point and on the south and west by Smith's Point. There is a 25 acre inner estuary, Hither Creek, in the southeast section of the harbor. The harbor shoreline is characterized by sand with some high dunes and vegetation on the north at Eel Point, a section of high dunes on a portion of the southwesterly side on Esther Island, the remainder by low sandy beach with some vegetation and minor dune formation. In the lower southern section, the shoreline has been breached to the Atlantic Ocean by storm damage at a point known locally as Broad Creek Opening. (See Plate No. 1, and Photo on the next page).



VIEW OF MADAKET HARBOR LOOKING WEST FEB 1976

Among the limited natural resources on Nantucket, Madaket Harbor is one of the most important, with extensive marshland, salt ponds and natural drainage creeks on its northern and eastern shores. In the past it has had an average depth of four feet with several natural deep channel areas. Large unshoaled portions of the harbor bottom have an extensive eel grass and vegetation base. The eel grass base sustains extensive shellfish propagation as well as a varied fish population. Since 1880, Madaket Harbor has been a commercial fishing area.

Tidal flats, beaches, and dunes with low vegetation including scrub pine characterize the Madaket area shoreline and uplands. Southerly portions near the harbor have a tendency to be unstable due to wind drifting of the beach sand, particularly during the winter months.

Over the last thirty years Madaket Harbor has increasingly been used for recreational purposes. The inner harbor is well suited for small boating, sailing and sport fishing. The proximity of the Atlantic Ocean on the southwesterly harbor exterior makes excellent surfing and swimming.

Scattered housing exists in Madaket, mostly concentrated along the Hither Creek estuaries and south to the breach area. Traditionally the area has been known as a summer colony with a few year-round resident commercial fishermen, and the buildings can be described as cottages with a small number converted to permanent residences.

Surrounded by water, Nantucket is moderated by ocean temperatures and has a generally mild climate with a lack of extreme range. In 1973, the annual average was 48.9 degrees fahrenheit. The climatological standard normal air temperature ranges from 31 degrees in February to 68.1 degrees in August. Precipitation, primarily rain, averages about 43.66 inches annually. The harbor is essentially ice-free, except for the Hither Creek estuary during the winter months of January and February.

Madaket Harbor is exposed to storm and hurricane activity, normally from the south. Between 1896 and 1962, a total of nine storms damaged the area, with breakthroughs at Smith Point occurring in 1954 and 1961. Local area flooding of significance took place in 1924 and 1938. Since the 1954 breakthrough occurred at the sandbar on the western tip of Smith Point and not in the Broad Creek area, it did not have a material effect on the interior harbor and remedial action was not initiated.

An average of more than forty local boats comprise the commercial shellfishing fleet during the year. These craft average 22 feet in length with a draft of one and one half feet. This number is increased to over 60 boats by Nantucket town fishermen during November and December if prices and yield are good. Prior to the breach in 1961 and the subsequent harbor shoaling, Madaket Harbor was one of the most productive shellfish areas in the Cape Cod area yielding a principal harvest of scallops.

The scallop fishery is the most important fishery in Madaket Harbor and has been most directly affected by the sand infiltration from Broad Creek opening. From 1953 to 1974, approximately 239,000 gallons of scallop meats were harvested with about 70 percent of the catch taken during the months of November and December.

Quahogs are fished regularly by two to four boats in the harbor and near shore between Tuckernuck and Madaket. Large quahogs have gradually disappeared from Madaket Harbor, washed out by tidal currents and shoaling from the breach. The catch declined from about 2,000 bushels in 1958 to 1,000 bushels in 1965. This level has been maintained since then by reliance on beds outside of the interior harbor.

An estimated 2,000 pounds of lobster are caught in the harbor annually.

The significant finfish species of Madaket Harbor are bluefish and bass. The annual harvest of finfish totals about 6,000 pounds taken by both commercial and sport fishermen. Definitive data was not available as to the proportionate amounts caught by each category.

An average of 7,000 pounds of herring and alewives are caught each year between March and May. Alewives are used for lobster bait not only in Madaket but also in other areas as well.

Eels and clams have minor significance as a resource and are used primarily for family consumption by local inhabitants.

At least thirteen species of shorebirds and waterfowl use Madaket Harbor during spring and fall migration periods with a smaller population overwintering. The area and its resources provide excellent opportunity for waterfowl hunting. However, an unstable, sandy bottom does not provide suitable habitat for either duck or geese, or other water oriented birds because a lack of bottom growing eel grass gives a poor feeding environment.

No historical or archeological sites appear to be effected by the closure of the breachway at Broad Creek or exist as a resource in the Madaket area.

HUMAN RESOURCES

According to the 1970 census, the year round Nantucket population was offically stated to be 3,774. The labor force including an influx of summer labor, stood at 3,430 in June 1973 and at 3,440 in June 1974 as reported by the Division of Employment Security, the Commonwealth of Massachusetts. Many local residents believe that the total permanent population is closer to a range between 4,800 and 5,600 people. The island summer population is four times the "off season" figure and approaches 16,000.

According to a sewer census taken in 1973-74 by the town officials, there are forty families living permanently in Madaket. There are, however, 438 dwellings in the area, a number reflecting the summer population increase, and the "summer-recreational" character of the harbor and including recent construction of 102 townhouse condominium residences. Based on this data, a summer population growth of ten times the "off season" figures appears to occur. This is two and one-half times the total Nantucket estimated summer seasonal increase.

Nantucket has been a popular summer resort since the late 19th century, and many of the population are engaged in some type of work related to tourism and recreation. Service industries, construction, retail stores, restaurants, hotels, rooming houses, financial institutions, and fishing typically characterize the opportunities for employment. Some residents also engage in minor home type manufacturing of items such as scrimshaw carvings, decorative wood products, kits and miscellaneous souvenirs. A number of residents fish part-time to supplement their normal diet and to obtain additional income.

DEVELOPMENT AND ECONOMY

The major sources of employment on Nantucket are tied quite directly to the total island enterprise of tourism and recreation.

Fishing is an indigenous source of employment with a local market as well as an off-island demand for finfish and shellfish. Madaket Harbor is a major island source of scallops, the most important fish catch exported in volume and value. Most of the forty families who live in the area fish for income.

Official data on Nantucket unemployment indicates that a seasonal variance ranging from 12 percent in winter to less than 3 percent in summer is a normal occurrence.

Nantucket may be reached by large and small boats or aircraft from several points on the mainland. The Madaket area can be reached by road from Nantucket Town, but harbor shoaling does not permit any type of ferry service either from the mainland or elsewhere on the island.

The approximately 94 miles of sandy beaches and bluffs, as well as the quaint character of Nantucket, have made the island a popular summer resort. The Madaket area, long considered very isolated by the island inhabitants, can no longer be so considered. There have been, and it appears there will continue to be, important increases in the recreational use of the land and water, including sport fishing, swimming and boating.

Madaket Harbor is an important island resource with respect to commercial shellfishing. Bay scallops are the major catch of value. Quahogs, lobsters and finfish such as bluefish and bass are also caught mainly for local consumption and diet supplement. The total value of commercial fishing on Nantucket is estimated to range between $300,000 and $600,000 annually. Madaket contributes between $90,000 and $130,000 to the island total economy largely between November and May, which is the "off season" for the tourist - recreation business.

Prices received by fishermen for their catches have risen dramatically in recent years. For example, the average price per gallon of scallop meat rose from $13.00 in 1969 to $25.00 in 1973. A bushel of quahogs brought $4.00 in 1965 and $25.00 in 1976. This price rise has cushioned the economic impact of a declining catch in Madaket Harbor. The estimated value for the entire fisheries catch between 1953 and 1973 for the harbor area

is 2.4 million dollars, or an average of approximately $120,000 annually. As many as 60 boats have fished the area commercially over the years. The Nantucket sea food dealers do not expect a price depression even if the local supply of bay scallops is increased by restoration of Madaket Harbor shellfish beds because there is a general scarcity of supply throughout the Cape Cod area.

PROBLEMS AND NEEDS

Madaket Harbor has provided Nantucket with an important fish resource satisfying a very real economic need for this island community. Breaching of the Broad Creek Barrier in 1961 resulted in the destruction of productive shellfish beds in the harbor. Sand shoaling has made harbor navigation hazardous. Needed employment, afforded by dither Creek boat yard is now threatened. The recreational emphasis characterizing area land use is also threatened.

The intent of the following pages in this section is to identify, describe and dimension the problems and needs associated with closure of the Broad Creek breach in Madaket Harbor and the dredging of the harbor bottom.

STATUS OF EXISTING PLANS AND IMPROVEMENTS

There are no existing Federal projects in the Madaket Harbor area on Nantucket Island. However in 1936 the Commonwealth of Massachusetts in conjunction with the town of Nantucket dredged a navigation channel starting from deep water at the entrance to Madaket Harbor at Eel Point and extending across the harbor to the

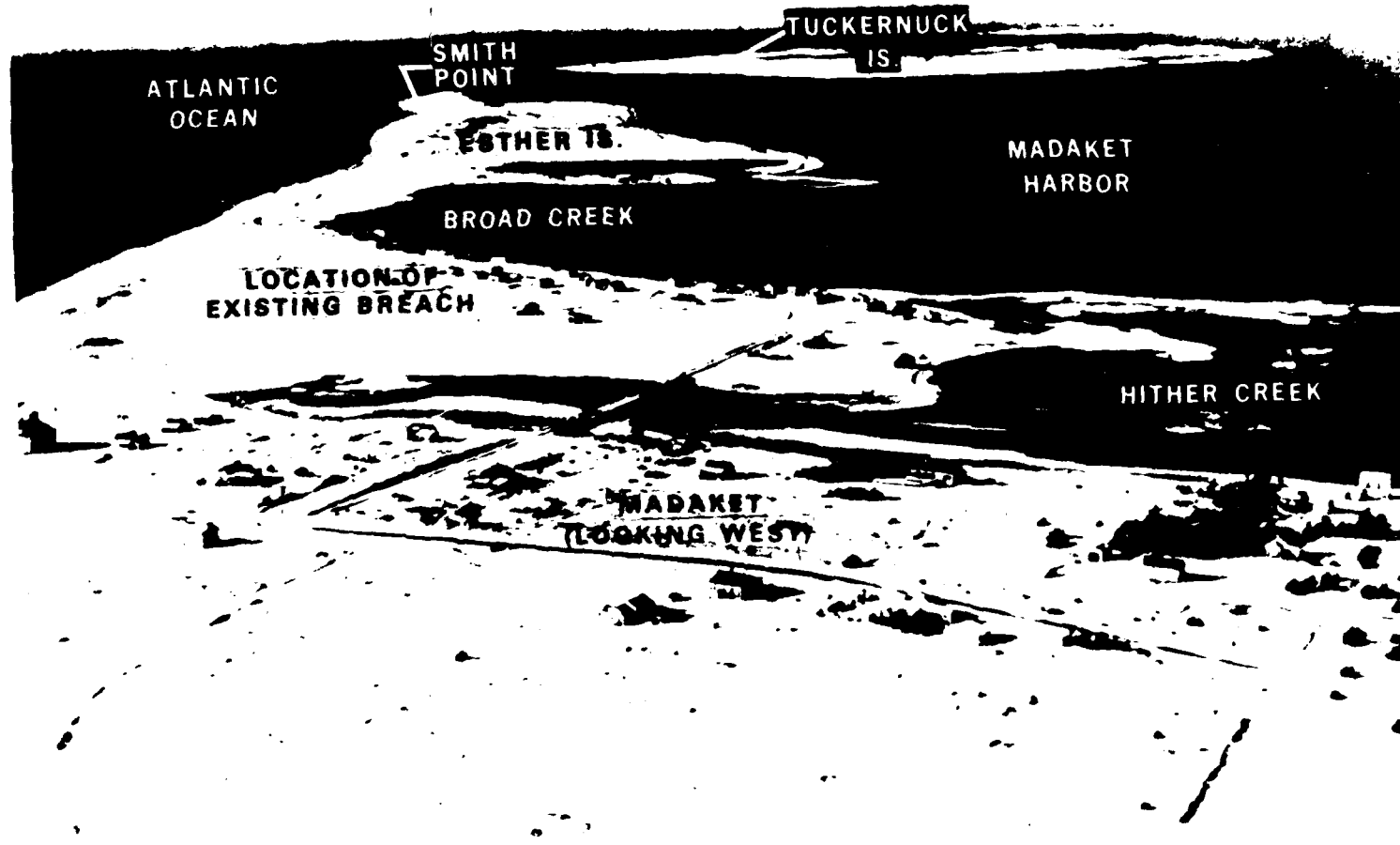
entrance to Hither Creek. At the same time a mooring basin was also dredged in Hither Creek. Both the channel and the mooring basin were initially dredged to a depth of 4-feet below mean low water (mlw). Since completion of the initial dredging both the channel and the mooring basin have been enlarged. Periodic maintenance dredging has been performed on an as needed basis up until 1970.

Madaket Harbor, prior to 1958, required infrequent dredging. A depth averaging 6.5 feet mlw was typical in the Hither Creek channel after dredging. Conditions as of 1974 prohibited safe passage for boats drawing three or more feet at times other than high tide.

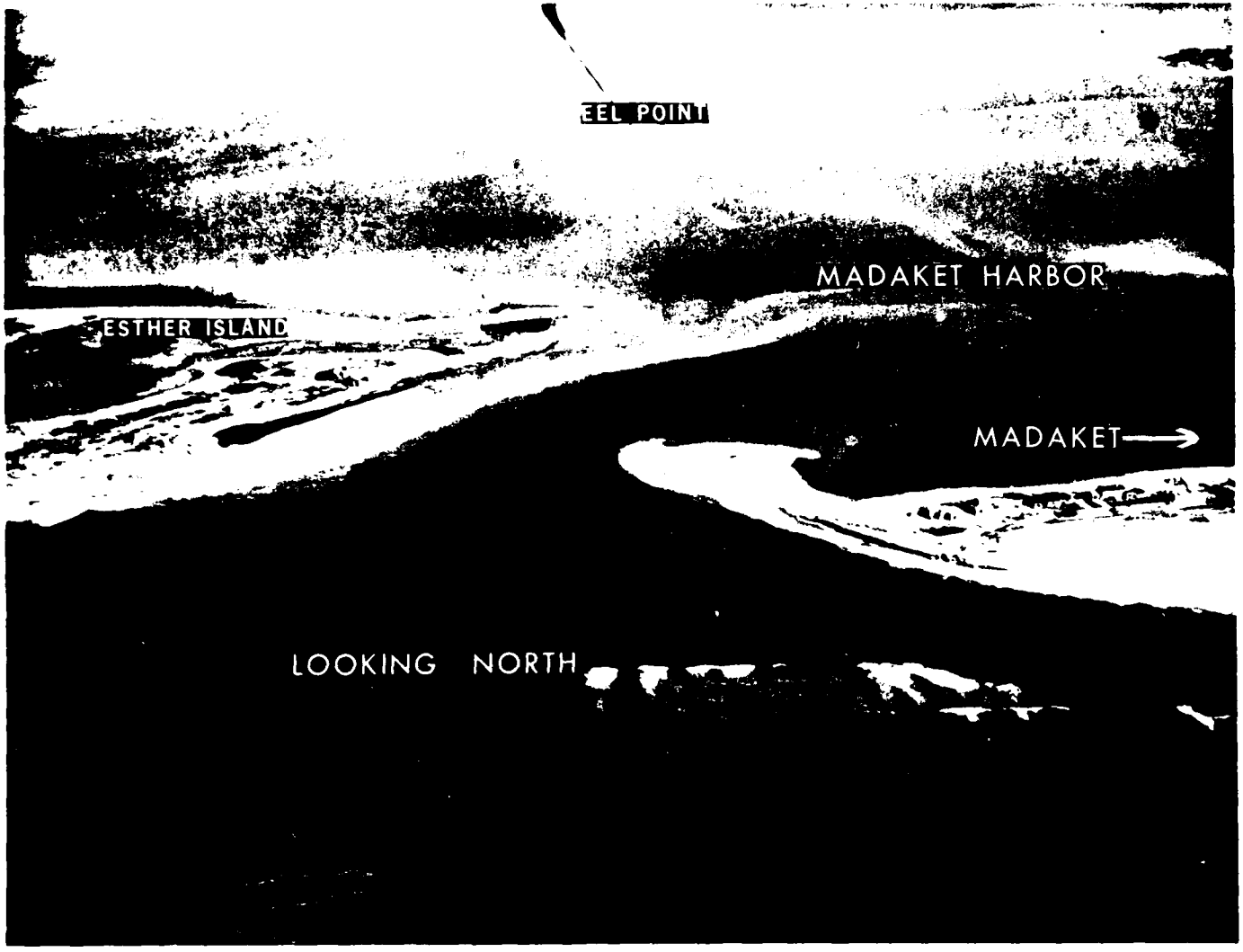
As was mentioned under the Section on Study Participants and Coordination with the formation of the Broad Creek Committee, Nantucket residents recognized the seriousness of the deterioration of Madaket Harbor. This committee prepared a report entitled, "C Harbor Dredging and Construction of a Reinforced Sand Jetty at Broad Creek Opening Madaket Harbor," which was presented to the Board of Selectmen and Finance Committee on June 25, 1970. In conjunction with the release of the report, a public hearing was held on navigation improvements of Madaket Harbor by the Department of the Army, New England Division, Corps of Engineers on the same date at the Nantucket High School. The consensus of the hearing and the committee report indicated that closure of the Broad Creek opening was not only desirable, but also necessary to preserve the water resources of the harbor area.

HARBOR DETERIORATION PROBLEM

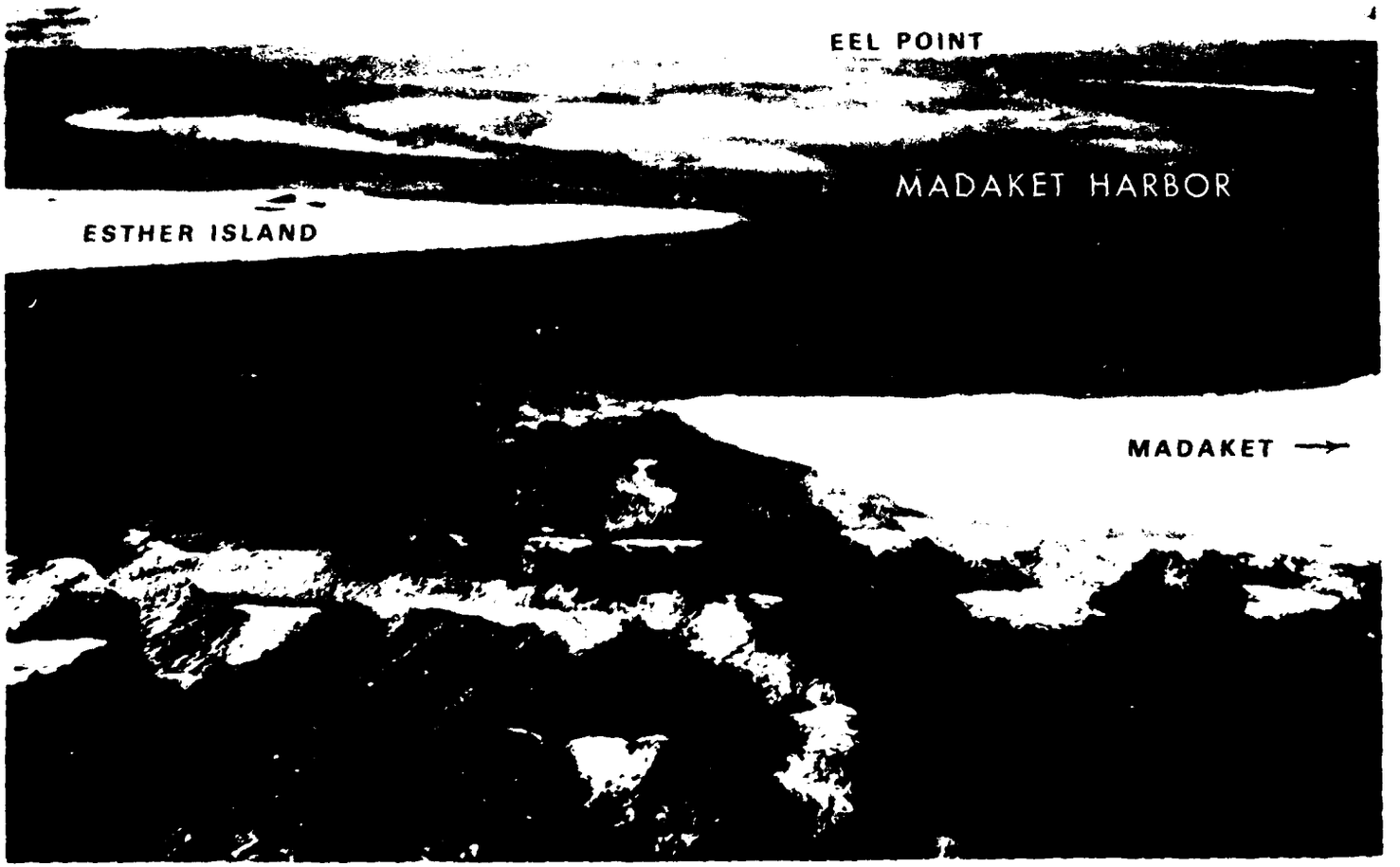
As a direct result of the Broad Creek Opening breach in 1961, approximately 800,000 to 900,000 cubic yards of sandy material had been carried into Madaket Harbor by mid 1974. Approximately 54 percent of the interior harbor of 746 acres now has an unstable sandy bottom which is nonproductive in terms of shellfish propagation. The channel from Eel Point to Hither Creek and the boat yard has been shoaled so that low water passage is essentially restricted to the boats drawing 1'6" or less, and the sand encroachment is



VIEW OF MADAKET HARBOR ON 15 DEC 1960 BEFORE BREACH



VIEW OF BREACH ON 19 OCT 1961



VIEW OF BREACH FROM OCEAN SIDE FEB 1976

MADAKET HARBOR
Looking Westerly 4/67
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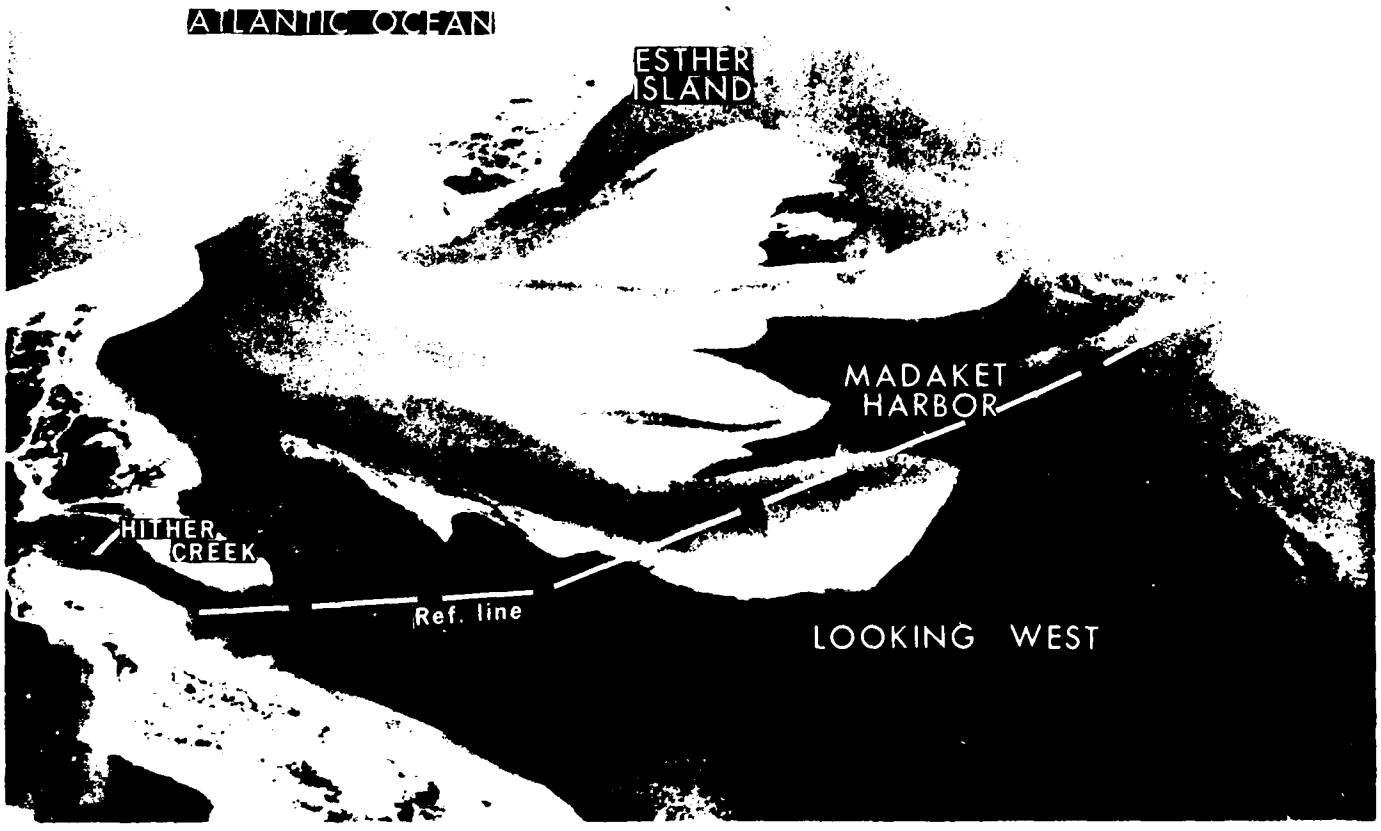
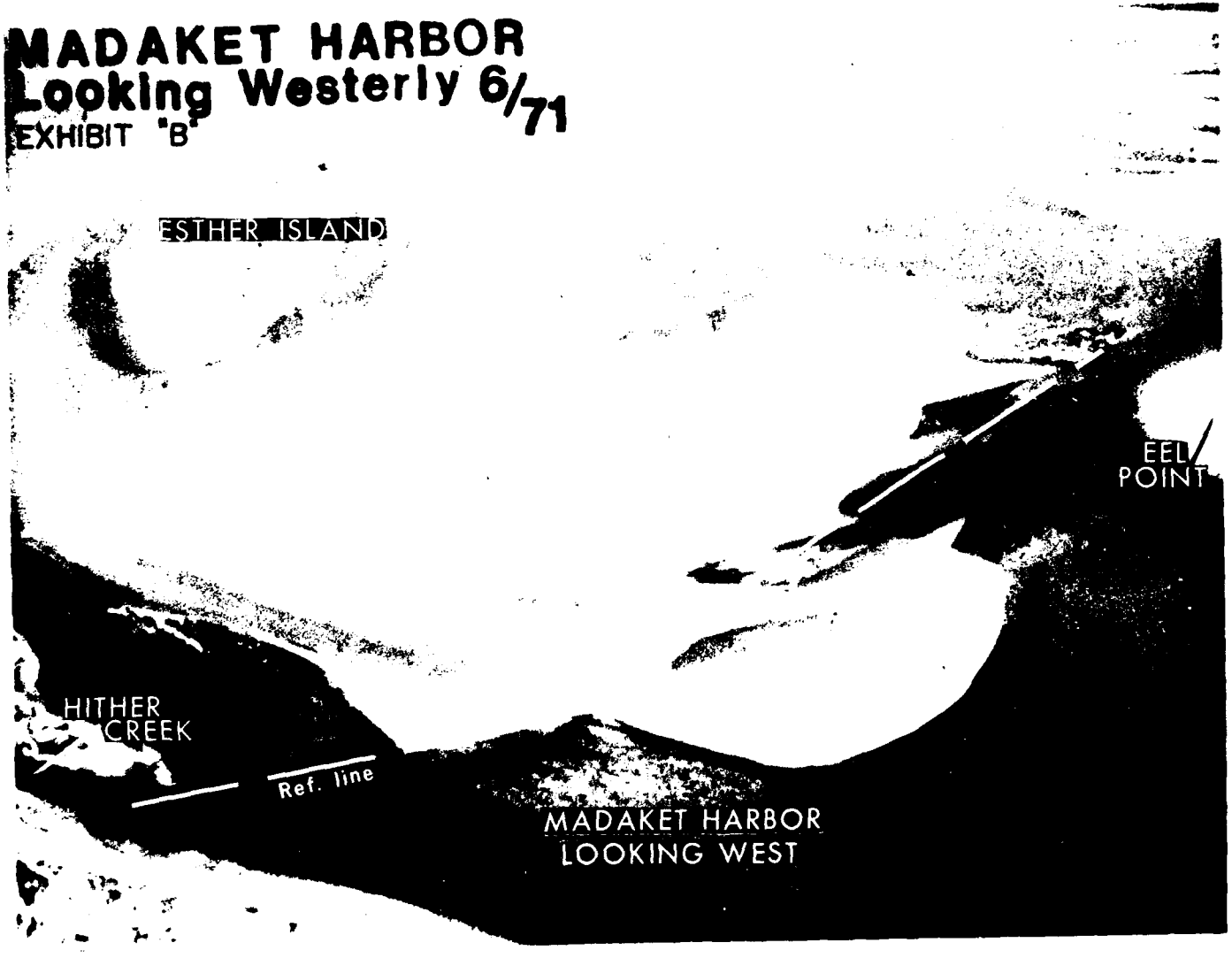


VIEW OF BREACH APRIL 1967 NOTICE LARGE SHOALED AREAS IN HARBOR

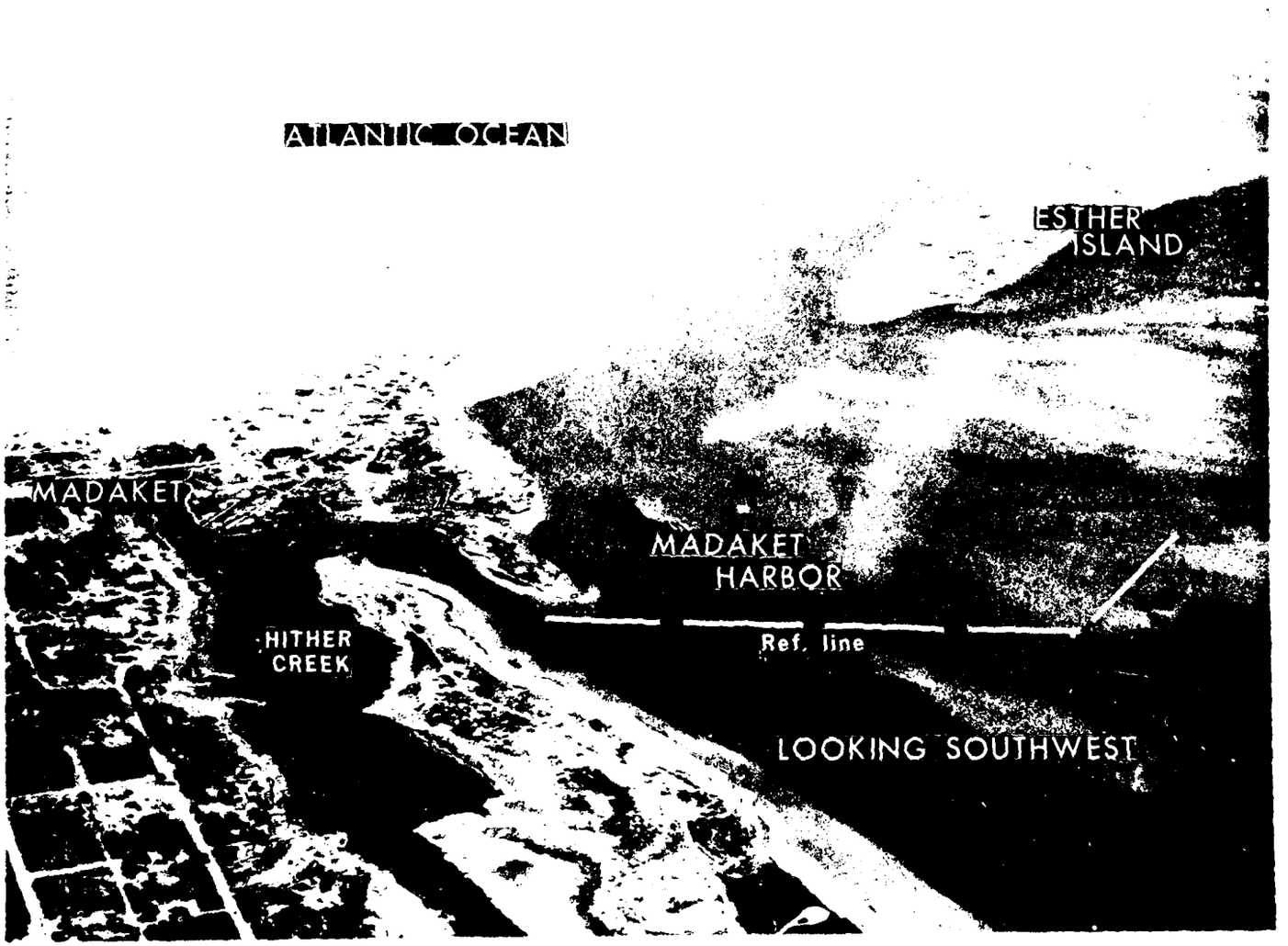
MADAKET HARBOR
Looking Westerly 5/70

VIEW OF BREACH MAY 1970

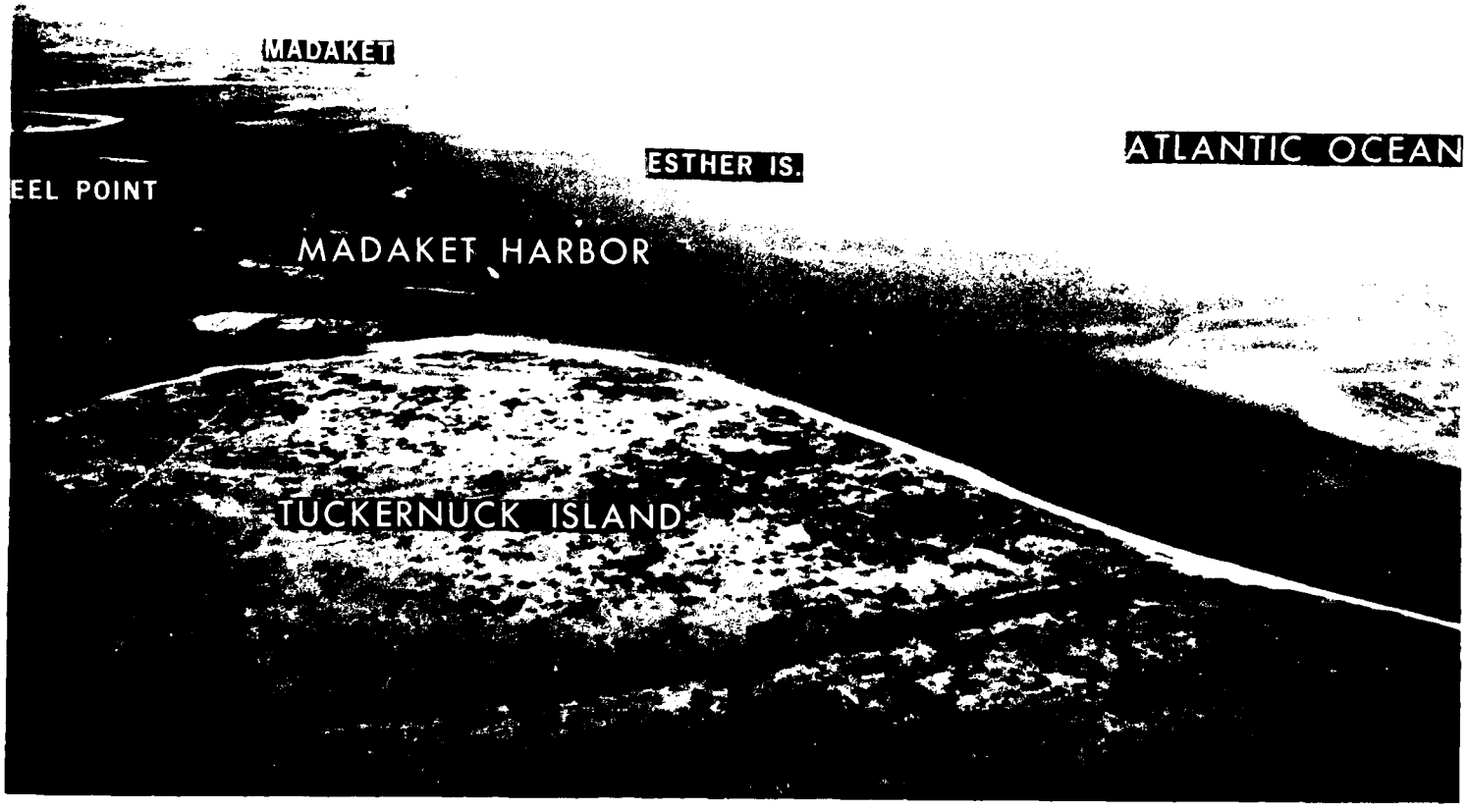
MADAKET HARBOR
Looking Westerly 6/71
EXHIBIT "B"



VIEW OF BREACH JUNE 1971



VIEW OF BREACH ON 24 FEB 1976



VIEW OF MADAKET HARBOR LOOKING EAST FEB 1976

spreading to the north each year. Harbor access from the west has been closed off by a sandbar and shoaling between Tuckernuck Island and the end of Smith Point even without major storm activity. The safety of recreational users of harbor waters, including the swimming public, is jeopardized by swift tidal currents flowing through the breach. Exposure through the breach to storms has made the harbor waters subject to disturbing wave and water current actions, limiting access to properties on Smith Point and making any human use of the harbor area more hazardous.

Shoreline recession caused by the breach has been dramatic in the Broad Creek area. Between 1958 and 1961, erosion destroyed one residence and caused ten other summer dwellings to be relocated from the Broad Creek shoreline. After the breach, the deterioration on the south shores adjacent to the breachway continued, and as the breach widened during the past ten years, Broad Creek and Narrow Creek on Smith Point were joined eliminating over seventeen land plattes and their interconnecting streets. In the winter - spring season of 1974 much of the westerly tip of Smith Point (Esther Island) disappeared forming a tidal flat and sandbar attached to the southwestern end of Tuckernuck Island. The loss of property and beach area has caused considerable concern to those with dwellings or land ownership nearby.

PRESERVATION OF MADAKET FISHERIES

Prior to 1958, Madaket Harbor required infrequent dredging. A depth averaging 6.5 feet (mlw) was typical in the Hither Creek channel after dredging. Present conditions prohibit safe passage for boats drawing three or more feet at times other than high tide.

Adequate access to the harbor will require channel dredging to a minimum 6-foot depth (mlw) from Eel Point to Hither Creek and the boat yard.

A deeper channel will benefit users of the boat yard since it will be able to handle more and larger craft. The scallop fleet will not only have a safer harbor for operations, but also will be able to increase its fishing area. There will be an increase in recreational boating activity since the harbor will be made less hazardous.

The extensive buildup of sand which handicaps the boatman has also adversely affected the supply of shellfish and finfish. If Madaket Harbor continues to fill with sand, the commercial scalloping industry will be more seriously impaired. As harbor depth decreases the stock of finfish will also decline.

Data obtained by the Broad Creek Committee from local sources indicates that the annual scallop harvest has declined by more than 50 percent since shoaling of the harbor began. It is apparent that, based on the scallop fishery alone, a need to preserve the total harbor fisheries is pressing.

The total economic, social and environmental impacts on Nantucket caused by the Broad Creek breach were not immediately felt except by local property owners who lost land and personal belongings to the sea in the hurricane of 1961. By the decline of the important scallop fishery, restriction of the boat yard business opportunities, and jeopardizing of recreational boating safety, the island inhabitants were made aware of the serious effect of the breach on their well-being.

IMPROVEMENTS DESIRED

A public hearing conducted by the Corps of Engineers, attended by eighty-eight Nantucket residents including the Broad Creek Committee, expressed the public concern for the deteriorating situation at Madaket. The Broad Creek Committee recommended that the breach be closed and the harbor restored to its prebreach condition to eliminate the hazards to navigation as well as save the shellfish industry and commercial and recreational boating use of Madaket Harbor. It further recommended that the closure take the form of a jetty filled with sand dredged from the center of the harbor. Concurrence with the Committee recommendations appears to be fairly universal on Nantucket, except for isolated individuals concerned about "tampering with nature."

FORMULATING A PLAN

A number of alternative methods afford solutions to the problems of improving the water resources of Madaket Harbor. The plan formulation portion of this study explored all potentially feasible alternative methods by considering technical, economic, environmental and social factors in the analysis.

FORMULATION AND EVALUATION CRITERIA

The planning objectives associated with a water resources improvement project in the Madaket Harbor area aimed at developing an economically feasible method to restore the shellfish beds and finfish population in the harbor, maintain a sufficient depth in the navigation channel to Hither Creek, and control shore erosion in the Broad Creek area. The following paragraphs discuss the technical, economic, environmental and socal evaluation criteria which were used in the process of selecting a plan which best meets overall objectives.

The technical criteria adopted for plan formulation requires that the selected plan be consistent with the local and regional plans for land use and water related activities. The selected plan should be of a magnitude adequate to endure a 50-year life span and flexible enough to accommodate future projected development.

The economic criteria requires that benefits for an improvement project should exceed costs. The analysis should also determine the point where the benefits exceed costs to the maximum extent possible (maximum net benefits). The costs of alternative plans of development are based on current prices, a 50-year period of analysis, and an interest rate of 6-3/8 percent. To make them comparative with the cost the benefits are also expressed in comparable quantitative economic terms to the fullest extent possible.

The environmental criteria considered in formulating a plan included, but were not limited to the minimizing of negative effects on marine life; the minimizing of negative effects on existing natural resources; and the restoration of the area environment to prebreach conditions.

The criteria applied to the social evaluation of a plan considered the effects of plan implementation on the human resources of Nantucket, the minimizing of adverse social impacts, and the maximizing of economic development in the project area.

POSSIBLE SOLUTIONS

All known feasible solutions to satisfy the need for improvement of the water resources of Madaket Harbor were investigated. They involve alternative methods for closure of the Broad Creek breach and restoration of the harbor as an economic resource. The following paragraphs describe and discuss the various alternatives evaluated.

CLOSURE BY NATURAL FORCES

Storm activity can bring about dramatic changes in topography, tidal flat, shoal and shoreline configuration in the Madaket area. Several local authorities felt that a storm could close the breach in spite of the fact that it has been established for more than fifteen years. In a southwest storm of sufficient intensity the sandbar formations offshore and south of the breach would supply sufficient material for closure and would themselves be replenished by littoral drift.

Historical records clearly indicate that current and wave forces over an extended time have progressively deteriorated the south shore of Nantucket, and eroded Smith Point. The creation of the breach opening established new forces further detrimental to Smith Point (Esther Island). The breach is now widening and water current forces will continue to erode Esther Island. In addition the buildup of sand deposits within Madaket Harbor will continue unless the breach is closed. Analysis of the water currents within the opening indicates that flood and ebb tides are eroding the eastern end of Esther Island as well as the mainland shore. During ebb tide this material is being deposited in sand rips immediately at the south entrance to the breach, and along with the normal westerly littoral drift material becomes available at flood tide for distribution in a northerly direction throughout Madaket Harbor. Nothing indicates that these past and present conditions will be reversed.

STONE AND RIPRAP JETTY SYSTEMS

The construction of a stone jetty system to assist natural forces in closing the opening is a method considered although it was recognized initially that the cost of transporting stone from a source to the project site would be high. The nearest source of suitable high specific gravity stone is the New Bedford area. Delivery and placement of the stone would require dredging an 8 foot, or deeper, channel both in Madaket Harbor and over the offshore bar from Nantucket Sound to allow passage of heavily loaded barges to the Broad Creek opening. This would create additional costs chargeable to this method. Shoaling and offshore wave condtions preclude water delivery from the ocean side.

The least costly way of supplying stone would require loading from the New Bedford area on barges and transporting it approximately sixty miles to Nantucket Harbor. After off-loading, the material would have to be hauled approximately seven miles over narrow town roads westerly to the project site. The final 400 feet would traverse beach sand which would have to be stabilized for passage of heavy vehicles. The stone would then have to be stockpiled and rehandled for placement. It is expected that the light duty town roads would be damaged by heavily loaded trucks.

As desirable aspects connected with a jetty of stone construction, closure of the breach would be accomplished without the requirement for the addition of a sand barrier and normal littoral and storm wave forces from the ocean side could be expected to assist in the deposition of sand reinforcement. Dredged sand from this and any future project within the harbor could be spoiled on the jetty to supplement natural sand accretion along the diked area. The dredging of selected areas for restoration of shellfish beds in the harbor would be an additional item of work to meet planning objectives by this method.

SUNKEN SCOWS AT SELECTED POINTS

Surplus barges, properly placed and sunk, afford a means to create natural shoaling and breach closure. Obstructions placed outside the breach would channelize water currents and create an additional source of sand. The barges could be moved to the site via Madaket Harbor under ideal conditions and be sunk to form the core of a reinforced sand barrier. However, serious questions of risk and liability were raised concerning towing from the nearest known source (New York City area) to Nantucket. Such barges, even when new, are designed for river traffic. After condemnation the risk of towing long distances in open water is great, even after action is taken to prepare the hull. The high technical and economic risk involved in attempting this alternative makes recommendation of this method of dike construction not warranted.

NON-REINFORCED SAND BARRIER

Direct deposit of sandfill in the breachway, without reinforcement combined with dredging selected areas in Madaket Harbor to provide for restoration of shellfish beds and navigation was considered as a method. Several unfavorable aspects of this method were revealed in the investigation.

High velocity current conditions, the rip character of the currents, and wave conditions at the project site would produce substantial backwash and undesirable shoaling in Madaket Harbor as a result of direct deposit of sand in the breach without reinforcement. The large size hydraulic dredge required to provide the volume of sand for rapid closure could not presently navigate to the project site from the harbor side. Furthermore, the source of the large amount of sand needed in a limited time would be of necessity from a confined area. Thus, the removal of sand backwashed into the harbor near the breachway and dredging selected areas for shellfish and channel restoration could not be accomplished in the same operation but would be an added item of work and cost. Further, because of the existing shoal areas, the tug tender would have difficulty with satisfactorily placing the large discharge pipes (30" diameter) used in this procedure. Dredging from the off-shore ocean side is even more questionable due to the seaward exposure, lack of accessibility, rip currents and wave character affecting the general safety of the large dredge.

REINFORCED SAND BARRIER

The deposit of sandfill and placement of steel sheet reinforcement was considered. Three types of steel sheet piling systems are feasible alternatives for reinforcement of a dredged sand barrier. These structures would permit a lower visible profile, be resistant to over-wash, and allow economy of construction and material, depending, of course, on the type employed. Rectangular and circular cell configurations, and a single sheet piling core were evaluated, as follows:

a. The Broad Creek Committee of the town of Nantucket recommended in their June 24, 1970 report that a sand barrier, dike or jetty be constructed, reinforced with rectangular steel sheet pile cells. This proposal would provide a stable and substantial core foundation on which to base a sand barrier structure. Further study, however, indicates problems in construction methods and cost factors with use of the rectangular cells recommended by the Committee. They require precision placement, wall and tie-rod reinforcement, and sufficient size for stability. The final breach closure under adverse current, weather and tide conditions inherent at the project site could create severe construction problems. The amount of steel required for the piling and appurtenant materials exceeds the quantities necessary for the circular cell or single pile systems. Construction labor cost is also greater due to more precise control needed for assembly of the cell bracing and support.

b. Circular sheet pile cells require less steel since they require no wall, or tie rod reinforcement, and can be made smaller with the same stability during construction. Placement requires less precision than rectangular cells, since there are fewer problems related to materials control and handling during construction. In both cases, however, final closure would require optimum current, tide and weather conditions.

c. Of the three sheet piling systems considered, the single sheet driven in-line appears to be most economical and practical under proper supervision and control. The reduced material requirements will lessen costs and handling. Less precision is needed during construction since the piles do not have to be driven in exact line. Proper job planning can solve a drawback in this plan of less stability provided during placement. Final closure may be somewhat more difficult but the time required for it will be reduced greatly because of the relatively simple structure and small amount of material to be handled under ideal conditions. Total costs are substantially less than for the other two types of reinforced dredged sand barriers. The sandfill deposited on both sides of the piling would be dredged from selected harbor areas and would promote restoration of the harbor.

PRECAST CONCRETE STRUCTURES

Beach protection methods as well as certain types of jetty and groin systems have successfully used precast concrete structures as a base. Under certain conditions, water and sand permeable configurations when placed parallel to beach lines will accrete sand for the purpose of increasing beach widths. Precast slabs set in a bulkhead along shore, or water jetted in place as a jetty, have been effective as a means to control erosion or to protect harbor and channel openings. However, in the case of the Broad Creek breach, the use of precast concrete units was considered to be less feasible than other approaches because of cost, and the conclusion that natural forces could not be controlled adequately during placement of the large, heavy slabs.

WOOD PILING METHODS

Traditional approaches to jetty, groin and bulkhead construction in New England have utilized wood piles and sheeting in many instances. The cooler average water temperatures of the region inhibit deterioration caused by marine life. This factor along with the availability and lower cost of wood make it an attractive material for coastal marine structures. However, placement problems associated with specific gravity and breakage make wood piles more difficult to work with in exposed locations, either alone, or in combination with sheeting, or with other material systems including old tires. Site conditions preclude the use of wood piling in the Broad Creek opening when compared to other methods.

SELECTING A PLAN

The seven approaches which were discussed in the previous section entitled "Possible Solutions" were evaluated to determine how closely they satisfied the planning objectives associated with a water resources improvement project in the Madaket Harbor area. The environmental consequence of each except that of closure by natural forces are similar insofar as closure of the Broad Creek opening is concerned. Primary impacts on the area concerned with construction

activity vary only in degree since all but closure by natural forces involve equipment and human activity on the project site and on local roads. The stone and riprap jetty alternative and nonreinforced sand barrier require added items of cost for dredging or transport of stone. Use of sunken scows, pre-cast structures or wood to effect closure must be rejected on the basis of site conditions and risks involved. Expectation of project accomplishment by natural forces is wishful thinking. On the basis of previous discussion and the comparision of alternatives outlined in this section, as relates to project technical, economic, environmental and social criteria, the alternative which best satisfied the needs and formulation criteria is a reinforced sand barrier system with a single steel sheet piling core. This plan will be hereafter referred to as the selected plan and is discussed in detail in the following section of this report.

THE SELECTED PLAN

This section presents a description of the project plan selected in the previous section on formulation. Significant information on design, construction, and operation and maintenance is given for the single sheet pile reinforced sand barrier so that the function and interrelationship of its components may be understood. In addition, this barrier system is evaluated with respect to how plan objectives are accomplished and what salient environmental and social effects it may have on Nantucket Island.

PLAN DESCRIPTION

The selected plan provides for closure of the Broad Creek opening with a structural system utilizing steel sheet piles, and dredged sand placed on either side, to form a dike configuration with a centered, hardened core. The closure must also be compatible with the abutting terrain so that storm action will not wash out unreinforced beach areas and weaken the end points. The barrier may be described in terms of its major components.

Effective c' ure of the Broad Creek breach can be accomplished by a dike structure 3,000 feet long, approximately 410 feet wide on the mean low water plane, with a crest elevation above mean low water of 11 feet. The sheet piling and sand comprise the major material components on the dike. (See Plate No. 2).

The sheet piling of corrosion resistant steel will provide the stabilizing core of the dike. The required sand fill will be obtained by dredging material from the main channel and other selected areas where shellfish bed restoration is desired in Madaket Harbor.

Erosion control for exposed beach surface areas on the barrier and adjacent sections must be instituted and maintained. The prevailing wind directly sweeps the open beaches causing wind drift and dune formation. To assist in reducing erosion of the sand barrier from wind effect, beach grass will be planted on the exposed sand as well as on nearby areas lacking vegetation. Every effort must be made to avoid indiscriminate use of wheeled or tracked vehicles after project completion on the dike or adjacent beach areas in order to preserve the designed topographic features of the sand barrier and the end transition sections on the mainland and Smith Point.

The plan also provides for restoration of the main channel to Hither Creek, the shellfish beds and the former numbers of finfish in Madaket Harbor by the removal of sand from selected areas in the process of getting sandfill for project construction.

EVALUATED ACCOMPISHMENTS

The selected plan for the improvement of water resources in Madaket Harbor will result in four evaluated accomplishments. They are as follows:

(1) Restoration of 300 plus acres of shellfish beds and an increased finfish population in the harbor.

(2) Restoration of the main channel to Hither Creek to permit safe navigation to the boat yard and anchorage for vessels drawing up to 5 feet.

(3) Control of shore erosion in the breachway area and shoaling in the harbor interior to prevent further loss of property and commercial fishing potential.

(4) Enhancement of the Hither Creek mooring area for recreational and commercial boating and ancillary development.

EFFECT ON THE ENVIRONMENT

A detailed assessment of the environmental impact of the selected plan appears in Appendix 2. The project objective is to restore the physical beach barrier and harbor waters to the pre-1961 condition. The restoration, consequently, will reestablish an environmental setting which formerly existed in the Madaket Harbor area. This process will be its ultimate primary near term impact. The long term primary and secondary impacts, therefore, become a forecast of what could have developed in the area subsequent to 1961 had the breach not occurred.

Immediate effects will result from the initiation of construction activity. Noise and air pollution will be evident from construction equipment, not only at the beach areas near the breach, but also from dredging operations in the harbor and truck traffic on nearby roads.

Hydraulic dredging operations will create some disturbance in harbor waters. Existing shellfish stocks will be temporarily affected in some areas by the dredging.

Closure of the breach will provide flood and wave protection to shoreline areas within the harbor. Harbor waters will be less affected by ocean swells and waves.

Deepening of the harbor may affect the local water temperature variation due to solar heating resulting in greater thermal stability beneficial to most forms of aquatic life.

While the selected plan will provide physical protection to harbor waters and enhance the prospects for the restoration of shellfishing as an island resource, increased recreational and commercial use in the long term will disturb wildlife in the shoreline marshes. While human habitation may not increase unduly, transient traffic will affect present air, water and acoustic pollutant levels.

ECONOMIC EFFECTS

A detailed evaluation of specific economic benefits and effects of the selected plan are described in Appendix 1, Section F, "*Economics of the Selected Plan*" and are also given in a more summarized form in the following section entitled "Economics of the Selected Plan." There are a number of other economic considerations, directly and indirectly attributable to, and resulting from the project which should be recognized to complete the picture. These items are difficult to quantify and give specific dollar values to even though they will very likely impact the Nantucket economy in the future.

There have been a number of Madaket Harbor and Hither Creek dredging projects accomplished jointly by the Commonwealth of Massachusetts and the town of Nantucket beginning in 1936, with costs ranging from $6,000 in 1936 to $97,000 in 1970.

Restoration of the barrier should reduce the needed main channel maintenance dredging frequency from an annual interval to a prebreach interval of 12 to 13 years. The state and town are presently responsible for maintaining the harbor channels.

Hither Creek boat yard stores approximately 120 boats and services 250 annually resulting in a gross income of $250,000 per year. A 10 percent rate of annual increase in gross income is a reasonable projection of expected growth due to channel restoration.

Time loss of operation for commercial fishing craft will be reduced by a deepened channel and harbor. Presently many boats using Madaket as their port must enter between one hour before and after high water. This approximately 2-1/2 hour time gate is a restriction which would be eliminated by an adequate channel to Hither Creek increasing the gross revenue potential of this business by allowing more flexibility of time for fishing.

A protected, safe harbor would provide tourism benefits with regard to small boat operation and bathing. Madaket's reputation as a "summer resort" area would be enhanced, attracting more visiting recreational boats from Nantucket Harbor as well as mainland ports. More attractive and safe beaches for swimming would have a desirable influence on property rentals in the area. Land access to Smith Point would allow less restricted opportunities for sport fishing by local as well as visiting enthusiasts. Property values in Madaket should appreciate at a rate greater than might be expected without the proposed project.

The construction of the project will provide payroll and service income to the total Nantucket economy. Housing and food service for contractor personnel as well as other miscellaneous transportation rentals, equipment suppliers and repair facilities will benefit directly during the construction period.

SOCIAL EFFECTS

The proposed breach closure and associated harbor dredging will produce social as well as economic benefits in the area. In general, the project is viewed by residents as positive to the economy of the Island and not injurious to either the people or the social/physical environment of either the Madaket area or the total island. Appendix 4 gives a more detailed social effects assessment associated with the selected plan.

The Madaket area, once looked upon as an isolated locale by the Island inhabitants, can no longer be so considered. There have been, and it appears there will continue to be, important increases in the recreational use of land and water. The harbor area is an important arena for commercial shellfishing. The past few years have also seen a rather rapid increase in residential use of the area.

The main industry, tourism and recreation, will continue to support directly or indirectly the economy of the area with or without the project. However, without the proposed project it appears that: there will be fewer alternatives for employment, a traditional industry (fishing) will be negatively affected, only one harbor and the resultant business surrounding it (Nantucket Harbor) will be able to grow and operate effectively, and boating will be less safe in the Madaket area. It does not appear that the area will be negatively affected in any significant fashion by the closing of the breach. It is true that Esther Island will once again become accessible from the mainland. Yet, if the operation of land vehicles is effectively controlled or eliminated in this area, the privacy of even the present seasonal residents of Esther Island should largely be unaffected.

The proposed project could be an important influence in the life of a significant portion of the Nantucket population. Increased shellfishing, one source of employment during the "off-season" (in contrast to the tourist/recreation season), could prove an effective means of helping to reduce the effects of poverty in the population. Secondarily, the project could operate as a morale incentive for many people. The feeling that someone cares about their livelihood could be important to morale if the project's positive results for the shell fisherman are emphasized and realized.

DESIGN

The proposed plan of improvement has been designed to fill the breach between the mainland and Smith Point (Esther Island) in order to prevent littoral drift along the south shores of these islands from being transported through the breach into Madaket Harbor. The closure would be accomplished using a structural system of steel sheet piles and dredged sand placed on either side to form a dike configuration with a centered, hardened core. The resulting dike structure is designed to withstand a recurrence of the most severe storm of record in the vicinity, which was Hurricane Carol of August 31, 1954. The sand material for the dike structure will come from the harbor dredging which is designed to restore over 300 acres of shellfish beds and increase the finfish population in the harbor.

Appendix 1, Section E gives a summary of the details of the design calculations which were developed in a previous report entitled "Study and Report of Closing Breach in Barrier Beach, Madaket Harbor, Nantucket, Massachusetts," which is referenced in Appendix 5. These detailed design calculations were used in designing the selected plan in this report.

CONSTRUCTION

In general, the closing of the breach at Broad Creek would be comprised of design and construction phases. Completion of these phases would result in closure of the breached area by a sand barrier with a steel sheet pile diaphragm. This construction would restore the shorelines in the breached area, while simultaneously returning

Madaket Harbor to a condition equal to or better than that existing prior to the breakthrough. These two phases would require a period of approximately two years for completion.

This site is unique with inherent problems for construction work. The following construction sequence and methods are therefore feasible but, with present data, do not necessarily reflect the ultimate in economy. Throughout the construction estimate, however, possible alternative methods will be noted. The following steps are recommended:

a. The Design Phase would require obtaining the following: subsurface exploration data, specific construction related water current and flow measurements, line contours of land and underwater areas at the breach, and the area of sand shoaling within Madaket Harbor.

The remainder of the design phase would include design engineering, preparation of contract plans and specifications, updating proposed construction methods, cost estimate, and hearings and reviews necessary for final approval. Completion of the design phase would require six to nine months.

b. Construction operations would be as follows. In preparation for actual construction of the sand barrier, dredging would be required of access channels with unloading areas near the ends of the proposed steel diaphragm, as well as delivery of materials and set up of equipment. Construction would start at the east end, on the Nantucket mainland, with the placing of about 150' of sheet pile core together with the transverse retaining sheeting and protective heavy riprap nosing. Upon completion of the above, the remainder of the closure work would proceed from the west end of the barrier on Esther Island with sheet pile placement and sand stabilization.

After making final closure, hydraulic dredging, grading, and sand fill stabilization would complete the replacement of the eroded material and would provide for restoration of shellfish beds by removal of sand from the main channel and selected harbor areas.

Completion of the hydraulic dredging in Madaket Harbor would restore the shorelines as shown on Plate No. 2. The type of the sand barrier berm (Elev. 11.0) would be matched to existing ground grade on both the mainland and Esther Island. Grading and soil stabilization with the planting of protective vegetation would complete the reinforced sand barrier construction.

ECONOMICS OF THE SELECTED PLAN

This section of the report deals with the economics associated with the selected plan. A discussion of the first cost, annual charges, benefits and justification is included. A more detailed estimate of costs and benefits are included in Appendix 1, Section F. .It should be pointed out that there are a number of intangible benefits such as enhancement of real estate values and social well being in the area which can be directly or indirectly attributed to the project. Unfortunately these items are difficult to quantify and to assign a specific dollar value to. Benefits can be given only to tangible items to which dollar values can be assigned.

METHODOLOGY

In order to establish the economic justification of the selected plan a comparison has to be made between the equivalent average annual charges (i.e. interest, amortization, and maintenance costs) and estimated equivalent average annual benefits which would be realized over the 50-year study life which was used. Appropriate values given to costs and benefits at their time of accrual are made comparable by conversion to an equivalent time basis using an appropriate interest rate. A directed rate of 6-3/8 percent applicable to public projects was used in this report. Cost estimates are based on prevailing February 1977 price levels.

COSTS

The estimated costs are for the construction of a barrier 3,000 feet long and include the reinforcing material costs as well as the dredging expense to provide the sandfill. In addition

the estimate includes post construction beautification and protection of the areas adjacent to the project site which involve primarily the planting of beach grass as well as clearance of the outer sandbar in Nantucket Sound in the channel approach to Madaket Harbor.

Contingency allowances of 15 percent for dredging and 20 percent for steel costs have been incorporated. Engineering and supervision have been included at 10 percent of construction cost as shown. Dredging of the outer bar in Natucket Sound has been included in the estimate to provide full channel depth into Madaket Harbor from approaches in the Sound. All prices are based on February 1977 costs.

FIRST COST ESTIMATE

ITEM	COST IN DOLLARS	
Dredging Harbor, 650,000 cy	$ 2,460,000	
Dredging Outer Bar, 15,000 cy	60,000	
Contingencies	380,000	
Subtotal		$2,900,000
Stone Riprap, 55,000 Tons	2,170,000	
Steel, 1,442,000 lbs	460,000	
Contingencies	520,000	
Subtotal		6,050,000
Beach Grass	70,000	
Subtotal		6,120,000
Engineering and Design	250,000	
Supervision and Administration	360,000	
TOTAL COST		$6,730,000

The following annual cost estimate is based on a 50 year project life. Interest during construction is not included since this period should require less than 2 years. Interest and amortization are based on a rate of 6-3/8 percent.

ANNUAL COST ESTIMATE

ITEM	COST IN DOLLARS
Interest & Amortization of Project Cost ($6,730,000 x 0.6678)	$ 450,000
Annual Maintenance	
Barrier	260,000
Aids to Navigation	5,000
Beach Grass	3 000
Channel Maintenance	10,000
TOTAL ANNUAL CHARGES	$ 728,000

BENEFITS

The derivation of benefits resulting from closing the breach and dredging the bay are based upon evaluation of "with" and "without" the project conditions.

The "without" the project conditions evaluate the existing physical and economic effect of the breach, shoaled bay and shifting sands upon the project area.

The "with" project conditions evaluate the future changes in the physical and economic status of the project area if a project were to be constructed.

The benefits evaluated for this study include restoration of the shellfish resource, reduction of future channel maintenance dredging, elimination of lost time and boat damage and increased recreational boating values. All benefits are termed "general" in nature except the recreational boating benefits which are 50 percent "general" and 50 percent "local". The shellfishing benefits were developed from the Fish and Wildlife report using two methods. The dollar values are representative of the ex-vessel prices of the catch based on 1976 price levels.

METHOD 1 is based upon the documented catch of prebreach conditions and does not reflect the potential of the future conditions.

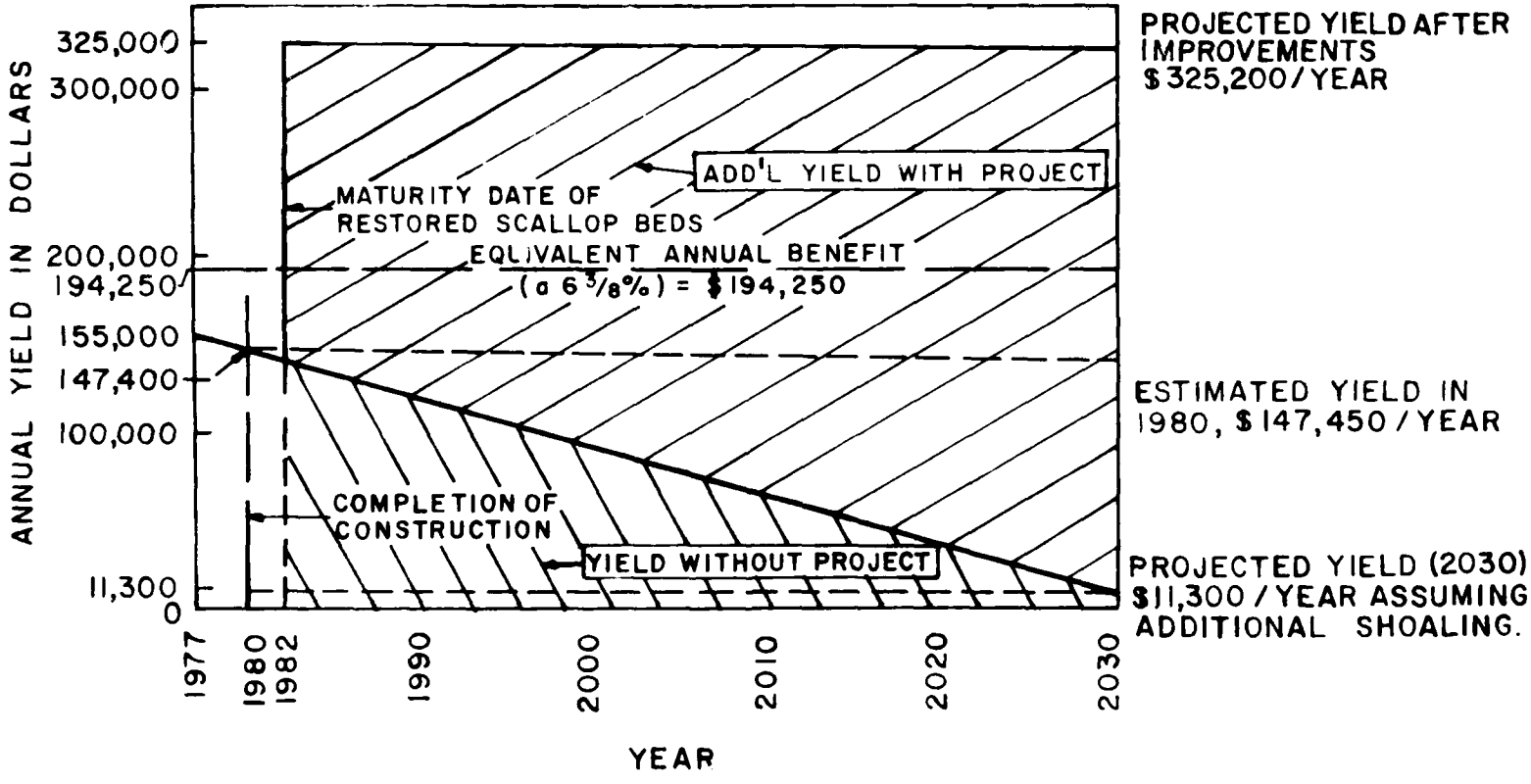
METHOD 2 is based on the documented catch plus the potential resource available for harvest dependent on several variables. These variables may include fishing pressure, marketability, available labor, and economic conditions such as costs of other luxury food items. It is also assumed that 395 acres covered by sand would reach the predicted level of productivity once the breach is closed.

METHOD 2 was used in the formulation of benefits for the study. This resulted in gross benefits of $177,750 for bay scallops and $69,125 for quahogs. The graphs on pages 41 and 42 represent the "with" and "without" project shellfish conditions. The benefits are the difference between these conditions. Because the re-establishment of the fishery would take a few years after project completion when no benefits would be obtained, the benefits must be redistributed over the 50 year project life using economic methods. Thus, the average annual gross benefits have been developed and are $194,250 for scallops and $53,180 for quahogs. A 6-3/8 percent interest rate has been used. The average annual benefits for scallops are higher than the gross benefits because the analysis over 50 years shows a continued shoaling and loss of the scallop resource. Thus the project would prevent future losses.

The average annual gross benefits must be divided into two categories. One is the cost of acquisition, which may include fixed and variable costs incurred by a fisherman to obtain a catch. The other is the return to the operator and is the net benefit attributable to the project. The return to operator or net benefit in the fisheries has been estimated at 40 percent of the average annual gross benefits. The project benefits from shellfishing are $77,700 for scallops and $21,300 for quahogs.

The elimination of lost time and boat damage has been estimated using information obtained from local fishermen. These benefits are based on an average season of 22 weeks and reflect the added cost to fishermen due to shoaling. This cost is estimated at $9,000.

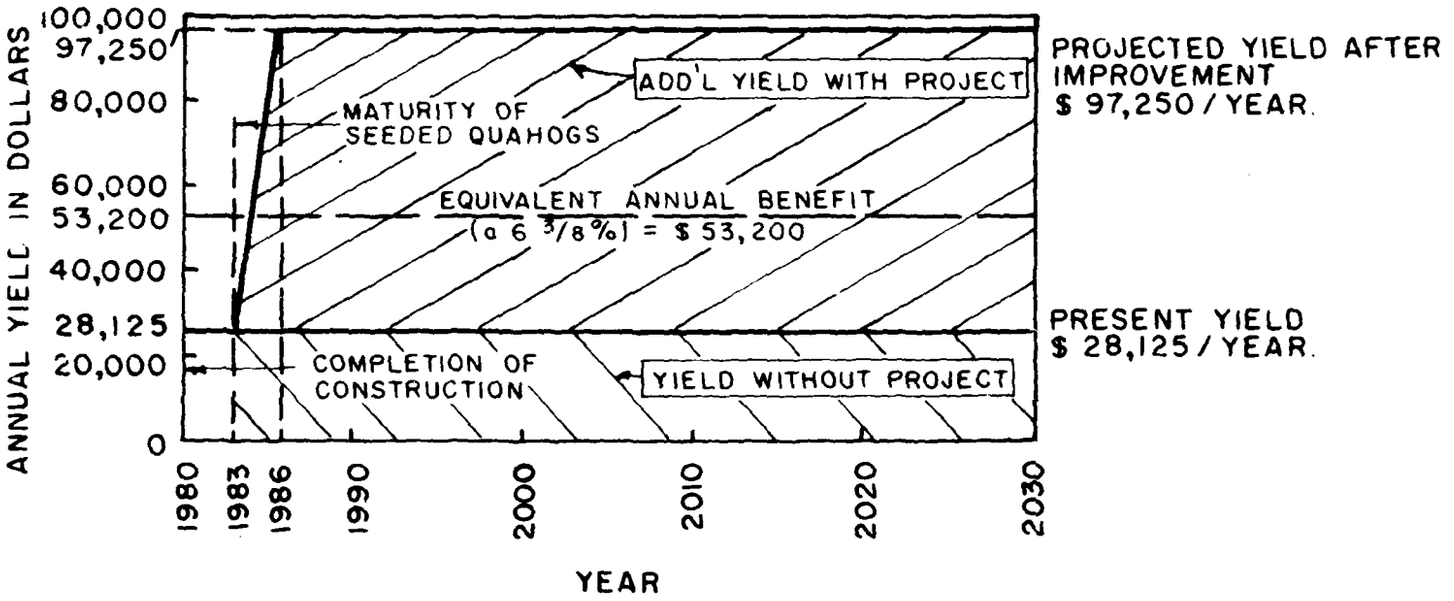
SCALLOP YIELD
MADAKET HARBOR
NANTUCKET, MASS.



Schematic of Benefits for Scallops

FIG. 1

HARD QUAHOGS YIELD
MADAKET HARBOR
NANTUCKET, MASS.



Schematic of Benefits for Quahogs

FIG. 2

The reduction of future channel maintenance dredging is considered to be a cost that would be eliminated if the project were constructed. This is estimated to reduce future costs by $22,000 every year.

The future benefits derived due to navigation improvements have also been estimated for recreational craft. This has been done for the existing fleet, visiting or transient craft and an additional number of vessels which would represent future growth of the fleet. These benefits have been estimated at $15,000 annually.

A summary of the net benefits is as follows:

ITEM	COST IN DOLLARS
Scallops	$ 78,000
Quahogs	22,000
Savings in time and boat damage	9,000
Savings in channel maintenance	22,000
Recreational boat benefits	15,000
TOTAL NET BENEFITS	$ 146,000

JUSTIFICATION

A comparison of the average annual benefits and the average annual costs along with the resulting benefit-to-cost ratio associated with the selected plan is shown below.

ITEM	COSTS IN DOLLARS
Average Annual Benefits	$ 146,000
Average Annual Costs	728,000
Economic Ratio Benefits/Costs	0.2

As can be seen the benefit-to-cost ratio associated with the selected plan is substantially less than unity. Based on this fact the selected plan does not have economic justification for Federal participation or cost sharing in its construction.

STATEMENT OF FINDINGS

Madaket Harbor is a deteriorating water resource important to the island of Nantucket. Since the Broad Creek breach, the recreational, tourist and commercial value of the area has been gradually decreasing. Local waters have become unsafe for bathing and navigation. The shellfish harvest has declined, and the economic health of Madaket's only established employer, Hither Creek Boat Yard, is being jeopardized. If these unfavorable trends are to be reversed a program to restore the physical assets of the harbor must be developed.

The study has reviewed and evaluated several approaches to solve the problems and meet the needs in the Madaket Harbor area. The results of this evaluation and the demonstrated interest of local authorities indicate that closure of the Broad Creek breach combined with harbor dredging is the most feasible way to restore and preserve the natural assets of Madaket Harbor. This solution would require a reinforced sand barrier 3,000 feet long extending from Madaket to Narrow Creek on Smith Point (Esther Island) and the dredging of approximately 650,000 cubic yards of sandy material from the interior harbor bottom.

Unfortunately the selected plan was unable to meet the economic justification test. The benefit-cost-ratio of the selected plan was found to be below 1.0 which is the minimum acceptable level for Federal participation and cost sharing.

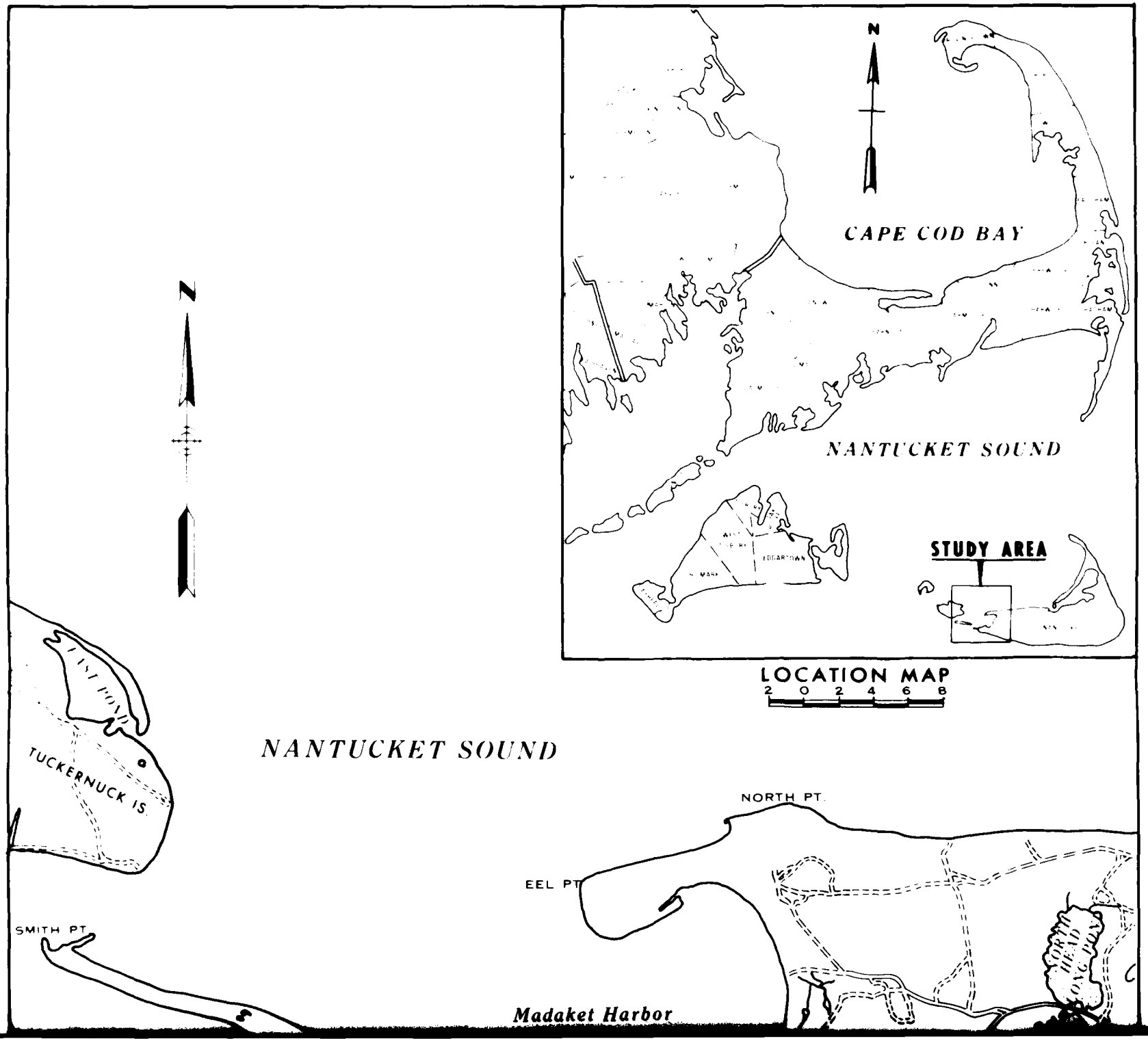
In general, from an environmental standpoint there are no long term adverse environmental impacts associated with the selected plan. Harbor restoration would have reestablished an environmental setting which formerly existed prior to the breach in 1961. Approximately 650,000 cubic yards of sand would be dredged from areas of shoaling in the harbor which have destroyed previously productive shellfish beds and limited navigation depths in the channel. While temporary disruption of the environment would occur during construction of the reinforced barrier, there do not appear to be any significant irreversible commitments adversely affecting the environment.

Even though the selected plan appears to be acceptable to local interests and the environmental and social aspects of the plan appear to be favorable, the unfavorable economics of the plan preclude it from Federal participation and cost sharing.

RECOMMENDATIONS

The Division Engineer recommends that no water resource improvement project be adopted at this time by the United States for Madaket, Smiths Point and Broad Creek, Massachusetts in the interest of flood control, hurricane protection, navigation and related purposes in light of the lack of economic justification.

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer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CAPE COD BAY
NANTUCKET SOUND
STUDY AREA
LOCATION MAP
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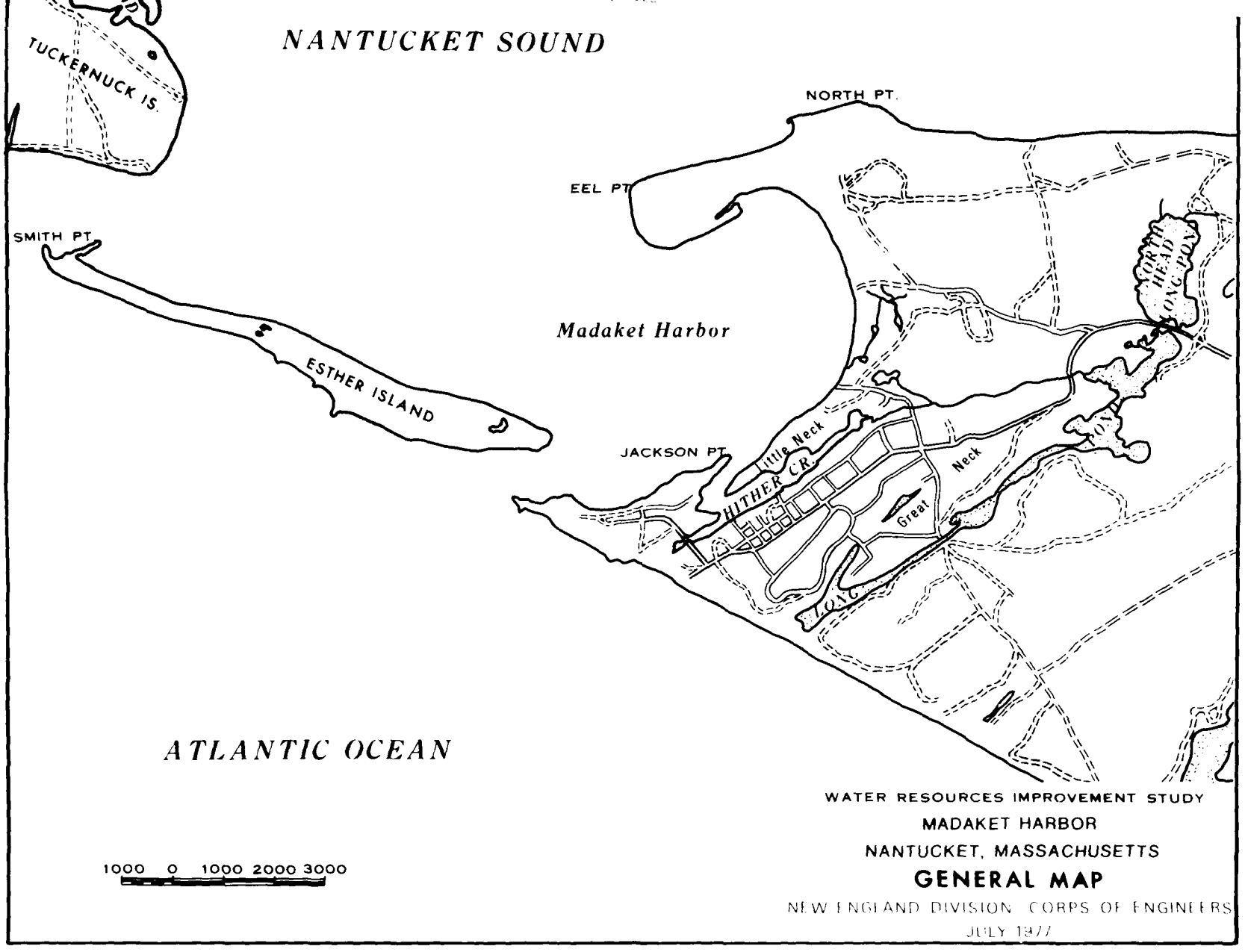
TUCKERNUCK IS.
SMITH PT.
NORTH PT.
EEL PT.
Madaket Harbor



WATER RESOURCES IMPROVEMENT STUDY

MADAKET HARBOR

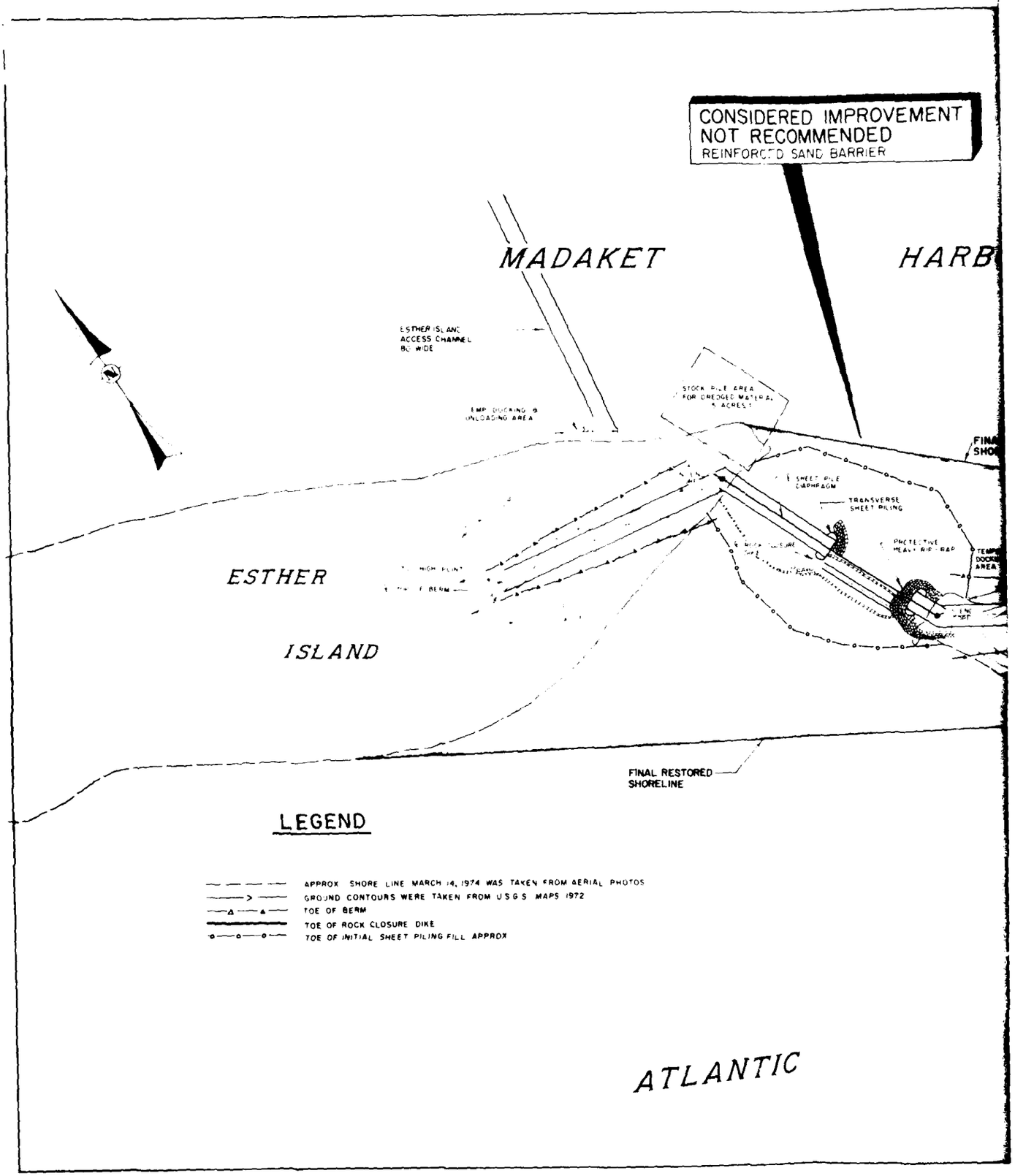
NANTUCKET, MASSACHUSETTS

GENERAL MAP

NEW ENGLAND DIVISION CORPS OF ENGINEERS

JULY 1977

PLATE 1


CONSIDERED IMPROVEMENT
NOT RECOMMENDED
REINFORCED SAND BARRIER
MADAKET
HARB
ESTHER ISLAND ACCESS CHANNEL
STOCK PILE AREA FOR DREDGED MATERIAL
EMP. DOCKING & UNLOADING AREA
SHEET PILE DIAPHRAGM
TRANSVERSE SHEET PILING
PROTECTIVE HEAVY RIP RAP
ESTHER
ISLAND
FINAL RESTORED SHORELINE
LEGEND
APPROX. SHORE LINE MARCH 14, 1974 WAS TAKEN FROM AERIAL PHOTOS
GROUND CONTOURS WERE TAKEN FROM U.S.G.S. MAPS 1972
TOE OF BERM
TOE OF ROCK CLOSURE DIKE
TOE OF INITIAL SHEET PILING FILL APPROX
ATLANTIC

NSIDERED IMPROVEMENT
T RECOMMENDED
NFORCED SAND BARRIER

HARBOR

FINAL RESTORED SHORELINE

SHEET PILE DIAPHRAGM

TRANSVERSE SHEET PILING

PROTECTIVE HEAVY RIP-RAP

TEMPORARY DOCKING AREA

NANTUCKET ISLAND

ROCK CLOSURE DIKE

OCEAN

ITIC

WATER RESOURCES IMPROVEMENT STUDY
MADAKET HARBOR
NANTUCKET, MASSACHUSETTS
CONSIDERED PLAN
U.S. ENGINEER DIVISION, CORPS OF ENGINEERS
JULY 1977

PLATE 2

APPENDICES

MADAKET HARBOR
NANTUCKET,
MASSACHUSETTS

FEASIBILITY REPORT

MADAKET HARBOR

NANTUCKET, MASSACHUSETTS

FEASIBLITY REPORT

WATER RESOURCES IMPROVEMENT STUDY

TECHNICAL REPORT

SECTION A : THE STUDY AND REPORT

SECTION B : RESOURCES AND ECONOMY OF STUDY AREA

SECTION C : PROBLEMS AND NEEDS

SECTION D : FORMULATING A PLAN

SECTION E : THE SELECTED PLAN

SECTION F : ECONOMICS OF SELECTED PLAN

APPENDIX 1

PREPARED BY
TIBBETTS ENGINEERING CORP.
NEW BEDFORD, MASSACHUSETTS
FOR
THE NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

SECTION A

THE STUDY AND REPORT

THE STUDY AND REPORT

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SECTION A

THE STUDY AND REPORT

1. A violent northeast storm, on September 20, 1961, caused a breach in the barrier beach located on the southern perimeter of Madaket Harbor known as Broad Creek. Subsequently, the breach has continued to enlarge so that, in 1974, it was approximately 1,200 feet wide and 20 feet deep maximum. Sandy material from the breach and littoral material from updrift beaches has been transported by local water current circulation and deposited in Madaket Harbor producing navigational hazards and related water resource problems in the harbor area.

Purpose and Authority

2. The purpose of the study is to collect and develop factual information on navigation, flood control and related water resource problems being encountered at Madaket Harbor, Nantucket, Massachusetts; recommend solutions that would alleviate such problems; and evaluate the environmental consequences of existing conditions and the environmental effects of any proposals made.

3. The authority for this project is derived from Section 219 of the Flood Control Act (Title II, Public Law 90-483), approved 13 August 1968 and is as follows:

> "Sec. 219. The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which includes the localities specifically named in this section after the regular or formal reports made on any survey authorized by this section are submitted to Congress, no supplemental or additional report or estimate shall be made unless authorized by law except that the Secretary of the Army may cause a review of any examination or survey made and a report thereon submitted to Congress, if such review is required by the national defense or by changed physical or economic conditions.
>
> "Maddaket, Smith's Point and Broad Creek, Massachusetts, in the interest of flood control, hurricane protection, navigation and related purposes."

Scope of the Study

4. The study and report was completed to determine the advisability and feasibility of navigation, flood control, and related water resources improvements at Madaket Harbor. Field research and analysis of the existing physical conditions in the harbor, reviews of previous reports and available recorded data, interviews with present residents and the preparation of this report in accordance with its purpose are the major elements of work.

5. The physical surveys, prior report data and interview procedures were in sufficient detail to establish basic information sufficent to permit plan selection and to determine proposed project feasibility, including environmental impacts. Socio-economic, environmental and related matters were coordinated with concerned agencies and the public. Much of the shellfish crop data was obtained from private records kept by individual fishermen and does not appear in Nantucket public records.

Study Participants and Coordination

6. As the deterioration of Madaket Harbor continued after 1961 and the decline of shell fishing developed an economic impact on the local community, a group of island residents were appointed to the so-called Broad Creek Committee for the purpose of recommending a remedial course of action. This committee of responsible Nantucket business and local government assisted in:

a. Providing access to island property records and other historical data connected with the Madaket area.

b. Directing the accumulation and recording of shell fishing data for Madaket going back to 1951.

c. Determining peak historical flooding elevations caused by storm activity in the harbor area.

d. Making the arrangements for interviews with individual residents concerned with harbor conditions, to determine the economic and the environmental problems associated with the breach.

e. Arranging for meetings of interested groups, including the Nantucket Conservation Commission, Nantucket Fishermen's Association, Nantucket Angler's Club and the Nantucket Civic League,

to obtain their views and background pertaining to the effects of the breach on the Madaket region.

f. Recommending a specific program of harbor dredging and breach closure utilizing some system of reinforced sand jetty construction.

7. Tibetts Engineering Corporation of New Bedford in close liason with the Corps of Engineers was responsible for the conduct and coordination of the technical study, consolidation of information from all sources, formulation of a plan and preparation of a preliminary report which is the basis of this report. The following is a listing and brief description of significant input sources which developed during the study.

a. Marine Research Inc. of East Wareham, Massachusetts under the direction of Dr. G.C. Matthiessen, contributed current data on the harbor shellfish crop as well as recommendations including technical data regarding future improvement of harvest based on dredged shellfish beds restored to productive condition.

b. The social effects, and segments of the economic effects, of the proposed breach closure were assessed by Dr. Harold F. Cooper, Associate Professor of Sociology at Cape Cod Community, College, West Barnstable, Massachusetts.

c. A previous feasibility investigation, dated June 20, 1973, and entitled "Study and Report on Closing Breach in Barrier Beach, Madaket Harbor, Nantucket, Massachusetts", by Tibbetts Engineering Corp., New Bedford, Massachusetts was the basis for the proposed plan selection incorporated in this report.

d. In addition, contact and coordination during the study was made with the Division of Marine Fisheries, Department of Natural Resources, Commonwealth of Massachusetts, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service.

8. On 7 March 1974 the Corps of Engineers held a public meeting with Town officials and interested groups in Nantucket to start the study process and obtain information concerning the needs, problems, and desires of local interests. During 1974 many workshops were held with input sources and local interests to formulate alternatives and evaluation methods. Completion of benefi analysis was accomplished in 1975 with coordination between the Corps of Engineers, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service. A final meeting was held on 24 February 1976 to inform the local interests of the study findings. Subsequently information consisting of the Tibbetts preliminary report, incorporating the other studies was furnished for their review.

The Report

9. This report has been arranged into a main or summary report and five appendicies.

10. The main report is a non-technical summation of the problems, needs and effects associated with improving Madaket Harbor by closure of the breachway and dredging a portion of the harbor. It presents a broad view of the overall study for the benefit of general and technical readers. Included are:a description of the study area and the present status of the harbor area, the needs for closure of the breachway and the problems connected with selecting a suitable plan, a description of the selected plan and its effects, a summary of the project economics indicating the benefit and the costs, the determination of justification for the selected plan and the recommendations of the Division Engineer.

11. Appendix 1 is a technical report following the same general outline and in accord with Department of the Army Regualtion ER1105-2-402 dated 3 December 1973. This material is in greater detail for the technical reviewer. It examines the problems and solutions in the same order as the main report but excludes subsequent plan implementation, coordination, and recommendations.

12. Appendix 2 is an Environmental Assessment based on the selected plan described in the main report. It examines the environmental setting without the project, the impact of the proposed action, adverse impacts which cannot be avoided, alternatives to the selected plan, relationships between local short-term uses of the environment and enhancement of long-term productivity as well as irreversible commitments of resources.

13. Appendix 3 is a report by Marine Research, Inc. which describes the present shellfish condition in Madaket Harbor and the technical and economic effects which may result from harbor improvement.

14. Appendix 4 is a Sociologists Report which assesses the social effects and segments of the economic effects of the selected plan. It includes the collection of background information regarding the social effects of the proposed project, interviews with the local population from 4 June 1974 through 7 June 1974, and an interpretive summary of this pertinent information.

15. Appendix 5 contains pertinent correspondence, reports of the U.S. Fish and Wildlife Service, and the design appendix of the 1973 Tibbets Report.

16. A prior report dated 24 June 1970 was completed by the Broad Creek Committee, appointed by the Board of Selectmen. It recommends closure of the breach and restoration of the harbor for the derived commercial, recreational and boating benefits to the island of Nantucket.

17. On 20 June 1973 Tibbetts Engineering Corp. completed a feasibility study to determine whether construction of a barrier system could be accomplished under conditions then existing in the harbor. This report concluded that a reinforced sand barrier using dredged sandy material from the harbor and having a steel sheet pile core was feasible.

SECTION B

RESOURCES AND ECONOMY OF STUDY AREA

RESOURCES AND ECONOMY OF STUDY AREA

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SECTION B

RESOURCES AND ECONOMY OF STUDY AREA

1. Individual native resources have a greater impact on the economic well-being and growth potential of an island that on a comparable mainland community. The following pages will provide an understanding of the environmental and human resources of Madaket Harbor and its development, economy and future as they relate to Nantucket Island.

Environmental Setting and Natural Resources

2. Madaket Harbor, the second largest harbor on Nantucket Island, has an interior area of approximately 746 acres. Located at the western extremity of Nantucket, it is bounded on the north by Eel Point and on the south and west by Smith's Point, as shown on Plate B-1. There is an inner estuary, Hither Creek, of about 25 acres in the southeast section of the harbor. The harbor shoreline is characterized by sand with some high dunes and vegetation on the north at Eel Point, a section of high dunes on a portion of the southwesterly side at Esther Island, the remainder by low sandy beaches with some vegetation and minor dune formation. In the lower southern section, storm action has breached the shoreline through to the Atlantic Ocean at a point locally known as Broad Creek Opening.

3. Among the limited natural resources on Nantucket, Madaket Harbor is one of the most important. It has extensive marshland areas, salt ponds and natural drainage creeks on its northern and eastern shores. In the past, it has had an average depth of four feet with several natural channel areas. Large unshoaled portions of the harbor bottom have an extensive eel grass and vegetation base, which sustains extensive shellfish propagation as well as a varied fish population. Since 1980, Madaket Harbor has been a commercial fishing area. Shellfish species include mollusks such as American

oyster, softshell clam, quahog and bay scallop, as well as crustaceans such as blue crab and lobster. Finfish varieties include alewife, bluefish, cunner, sand dab, American eel, flounder, white hake, tom cod, striped bass, and tautog.

TERRAIN AND LAND USE

4. Tidal flats, beaches, and dunes with low vegetation, including scrub pine, characterize the Madaket area shoreline and uplands. Southerly portions near the harbor have a tendency to be unstable due to wind drifting of the beach sand, particularly during the winter months. Maximum elevation of terrain bordering the harbor is 20 feet above mean sea level occurring north of Warren's Landing and west of Eel Point Road. The major portion of the breach and the balance of Madaket is elevation 10 feet or less, except for individual sand dunes which may exceed this height in places.

5. Over the last thirty years Madaket Harbor has been used increasingly for recreational purposes. The inner harbor is well suited for small boating and sailing. The Atlantic Ocean on the southwesterly harbor exterior is excellent for surfing and swimming. The Hither Creek estuary has protected moorings for more than 75 boats and is a base of operations for a commercial shellfish fleet of thirty or more boats during the season. Since 1967 the boat yard at the eastern inner estuary has invested in new equipment and is capable of servicing commercial and recreational craft up to 40 feet in length.

6. Scattered housing exists in Madaket, mostly concentrated on the Hither Creek estuaries and south to the breach area. Traditionally, the area has been known as a summer colony with a few year-round resident commercial fishermen and the buildings can be described as cottages with a small number converted to permanent residences.

CLIMATE

7. Surrounded by water, the Island has a climate moderated by ocean temperatures and generally mild with a lack of extreme range. In 1973, the average annual temperature was 49.5° Fahrenheit. The climatological standard normal temperatures range from 31.4° in February to 68.1°

in August. Precipitation, primarily rain, averages about 43.66 inches annually. The harbor is essentially ice-free, except for the Hither Creek estuary during the winter months of January and February.

8. Madaket Harbor area is exposed to storm and hurricane activity, normally from the south. Between 1896 and 1962, a total of nine storms damaged the area, with break-throughs at Smith Point occurring in 1954 and 1961. Local area flooding of significance took place in 1924 and 1938. Plate B-2 details the shoreline damage which has occurred on Nantucket.

FISHERIES

9. Historically, an average of more than forty local boats comprise the commercial shellfishing fleet. These craft average 22 feet in length and a draft of 1'6". This number is increased to over 60 boats by Nantucket Town fishermen during November and December if prices and yield are good. Prior to the breach in 1961 and the subsequent harbor shoaling, Madaket Harbor was one of the most productive shell fish areas in the Cape Cod area, yielding a principal harvest of scallops.

10. The scallop fishery is the most important in Madaket Harbor and the one most directly affected by the sand infiltration from Broad Creek opening. Since 1953, approximately 239,000 gallons of scallops have been harvested, with about 70% of the catch taken during the months of November and December.

11. Between 30 and 50 lobster pots are set in the harbor and along shores adjacent to Tuckernuck Island. At least two boats are engaged in this fishery from May to October, supplying mainly local Nantucket restaurants. An estimated 2,000 pounds are caught each year.

12. Quahogs are fished regularly by two to four boats in the harbor and near shores between Tuckernuck and Madaket. Large quahogs have gradually disappeared from Madaket Harbor, washed out by tidal currents and covered by shoaling from the breach. The catch declined from about 2,000 bushels in 1958 to 1,000 bushels in 1965. This level has been maintained since by reliance on beds outside of the interior harbor.

13. The significant fin fish species of Madaket Harbor are bluefish and bass. These are caught in Eel Point Narrows and in waters of the outer areas of the harbor. From late spring to early fall, local markets and restaurants are supplied with a total of about 6,000 pounds of fin fish annually.

14. An average of 7,000 pounds of herring and alewives are caught each year between March and May. Alewives are used for lobster bait in Madaket and other island areas.

15. Eels and clams have minor significance as a resource. Generally, eels are taken in winter through ice in Hither Creek. Clams are dug by local inhabitants for family consumption.

WILDLIFE

16. Shorebirds and waterfowl use Madaket Harbor during spring and fall migration periods, with a smaller population over-wintering. Eider, old squaw, scoter, scoup, goldeneye, bufflehead, widgeon, canvasback, mergansers, black duck, mallard and Canada goose are the principal species found in harbor waters during some part of the year. Between 20,000 and 25,000 scoters alone are recorded during peak migration periods. The area and its resources provide excellent opportunity for waterfowl hunting. Since the 1961 breach, the harbor bottom has become increasingly sandy and unstable. This does not provide a suitable habitat for ducks, geese and other water birds because the lack of bottom-growing eel grass gives a poor feeding environment.

HISTORICAL - ARCHEOLOGICAL SITES

17. No historical or archeological sites would appear to be affected by the closure of the breachway at Broad Creek or exist as a resource in the Madaket area.

Human Resources

POPULATION CHARACTERISTICS

18. According to the 1970 census, the Nantucket year-round population was officially stated to be 3,774. The last state census taken in March 1971 was 4,290. Many local residents believe that present total permanent population is closer to 4,800 to 5,600 people. The summer population estimated by

Zube in the Massachusetts Heritage (Vol. V, No. 1, April 27, 1967), is four times the "off-season" figure and approaches 16,000. The labor force in June 1973 stood at 3,430, and in June 1974 at 3,440, as reported by the Division of Employment Security, the Commonwealth of Massachusetts. These figures include all those persons 16 years of age and over who did any work for pay or worked in a family business for at least 15 hours during the week without pay. Imported and transient workers, of whom there is a large summer influx, are also counted as part of the available labor force.

19. According to a sewer census taken in 1973-74 by town officials, there are forty families living permanently in Madaket. There are, however, 336 dwellings in the area which reflect the summer population increase,and the "summer-recreational" character of the harbor. Recent construction of town house type condominiums provide approxmately an additional 102 residences, for a total of 438 dwellings in the Madaket region. Based on this data, a summer population growth of ten times the "off-season" figures appears to occur, which is two and one-half times the total Nantucket estimated summer seasonal increase by Zube. The sociologists report (Appendix 4)suggests that the year-round population growth in Madaket is slow, and that there is a rather rapid seasonal growth. Both of these trends should continue in the near future.

MAJOR SKILLS AND OCCUPATIONS

20. Nantucket has been a popular summer resort since the late 19th century. Occupationally, therefore, many of the population are engaged in some type of work related to tourism and recreation. Service industries, construction, retail stores, restaurants, hotels, rooming houses, financial institutions and fishing typically characterize the opportunities for employment of island residents. Minor home type manufacturing occurs producing items such as scrimshaw carvings, decorative wood products, kits and miscellaneous souvenirs for sale to tourists and other transient visitors. In addition to their regular occupations, a number of residents fish part time to supplement their normal diet and obtain additional income.

21. Educational opportunities for island residents are available through high school. The number of years of education completed for year round residents compares favorably with other populations in the Commonwealth partly as a result of in-migration of some portion of the population with high educational characteristics and the slow but continuous out-migration of a portion of the younger population

The traditional family occupations followed, such as fishing and construction, do not require higher levels of education, anyway.

Development and Economy

EMPLOYMENT-SEASONAL EFFECTS

22. The major sources of employment on Nantucket are tied quite directly to the total island enterprise of tourism and recreation. Fishing is an indigenous source of employment with a local product market as well as an off-island demand for fin fish and shell fish. Madaket Harbor is a major island source of scallops, the most important fish catch exported in volume and value. Most of the forty families residing in the area fish for income.

23. Official data on Nantucket unemployment indicate that a seasonal variance ranging from about 12% in winter to less than 3% in summer is a normal occurrence. Masssachusetts Division of Employment Security statistics show eighty people unemployed for the month of June 1974 (2.3%) at the start of the tourist season, based on a labor force of 3,440 people. There may be more actual unemployment since a number of year-round residents, either do not work in covered occupations, or are not disposed to report their predicament to the Division.

TRANSPORTATION SERVICES

24. Nantucket may be reached by boat or aircraft. The Woods Hole, Martha's Vineyard and Nantucket Steamship Authority operates frequent year-round passenger and vehicle transportation service from Woods Hole on the mainland. In the summer, passenger and vehicle service is provided from Hyannis. Air New England and Executive Airlines operate frequent year-round scheduled air service. A number of special charter air services are also available in the summer from Boston, New Bedford and Hyannis. Frequent daily boat trips are operated from Falmouth and Hyannis by independent ship lines during the summer.

25. Rental vehicles and taxis comprise the important public land transportation services on Nantucket. The Madaket area can be reached only by road from Nantucket Town since harbor shoaling does not permit any type of ferry service either from the mainland or elsewhere on the island.

TOURISM AND RECREATION

26. The approximately 94 miles of sandy beaches and bluffs, as well as the quaint character of Nantucket, have made the island a popular summer resort. The summer resident population, occupying seasonal dwellings and locally owned rental properties, exceeds 16,000 people. Transients, on day trips by ferry and visiting pleasure boats increase this total by at least 1,000 people on average, concentrated largely in the town of Nantucket.

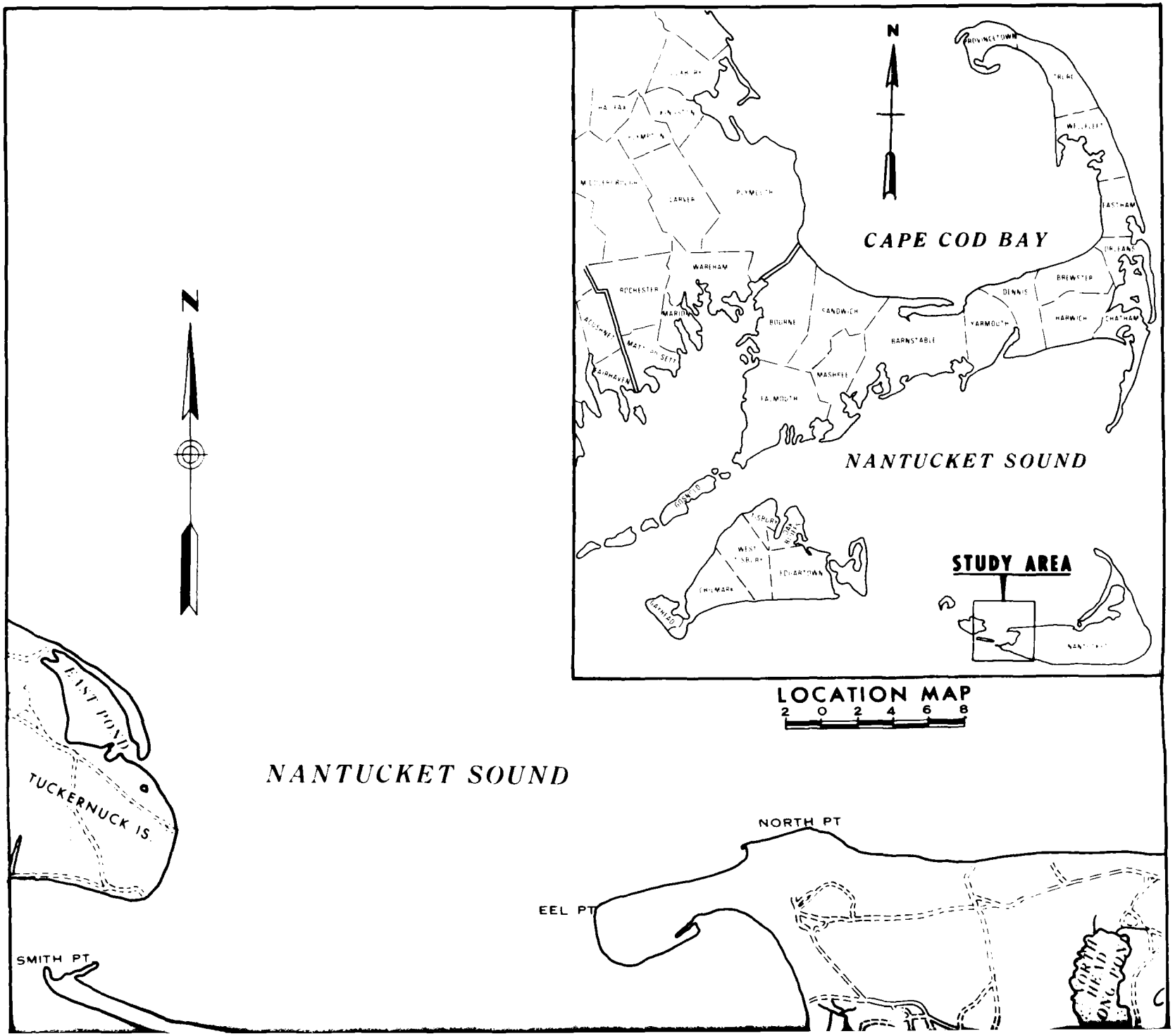
27. Nantucket offers seclusion and isolation from mainland activity. Madaket is attractive, even to permanent year-round inhabitants, for the same reason, in view of the higher pace of human activity in Nantucket Town. Uncrowded beaches, relatively low traffic volume on local roads, and the generally undisturbed features and topography are great recreational assets.

28. The Madaket area, long considered an isolated locale by the island inhabitants, can no longer be so considered. There have been and it appears there will be important increases in the recreational use of land and water, including sport fishing.

COMMERCIAL FISHING

29. The Madaket Harbor area is an important island resource with respect to commercial shellfishing. Bay scallops are the major catch of value. Quahogs, lobsters, and finfish such as bluefish and bass are also caught mainly for local consumption and diet supplement. The total value of commercial fishing on Nantucket is estimated to range between $300,000 and $600,000 annually depending upon weather and environmental conditions affecting propagation. Madaket contributes between $90,000 and $130,000 to the current island total largely between November and May, which is the "off-season" for the tourist-recreation business. These estimates were provided by local sources, particularly members of the Broad Creek Committee. Three dealers, Island Sea Food, John Betts and Elliot Sylera, buy and export all of the island's marketable bay scallops, including Madaket's. Only 10% of the fin fish and clams caught are sold off-island, the rest being consumed locally by Nantucket residents and restaurants.

30. Prices received by fishermen for their catches have risen dramatically in recent years. For example, the average price per gallon of scallop meat has risen from $13.00 in 1969 to $25.00 in 1973 and has remained near this level to 1976. A bushel of quahogs averaged $4.00 in 1965, $14.00 in 1972, and $25.00 in 1976. This price rise has cushioned the impact of a declining catch in Madaket Harbor. The estimated value for the entire fisheries catch between 1953 and 1973 for the harbor area is 2.4 million dollars, or an average of approximately $120,000 annually. Between 35 and 40 boats have fished the area commercially over the years. The Nantucket seafood dealers do not expect a price depression if the supply of bay scallops is increased by the restoration of Madaket Harbor shellfish bed since there is a general scarcity in the Cape Cod area and a continuing market demand.


N
CAPE COD BAY
NANTUCKET SOUND
PROVINCETOWN
TRURO
WELLFLEET
EASTHAM
ORLEANS
BREWSTER
DENNIS
HARWICH
CHATHAM
YARMOUTH
BARNSTABLE
SANDWICH
BOURNE
MASHPEE
FALMOUTH
WAREHAM
ROCHESTER
MARION
PLYMOUTH
CARVER
NANTUCKET
EDGARTOWN
STUDY AREA
LOCATION MAP
2 0 2 4 6 8
N
EAST POINT
TUCKERNUCK IS.
NANTUCKET SOUND
NORTH PT
EEL PT
SMITH PT

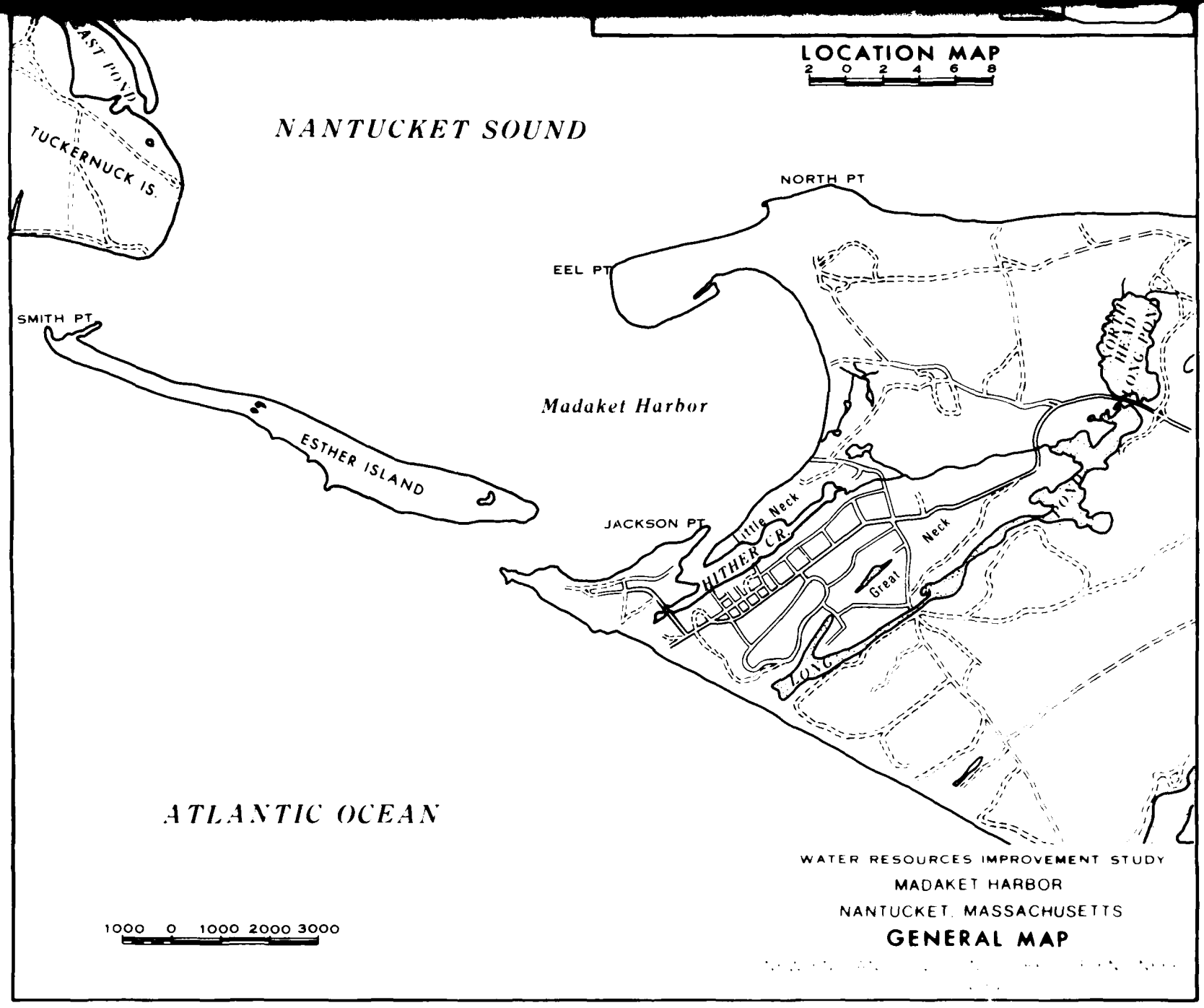
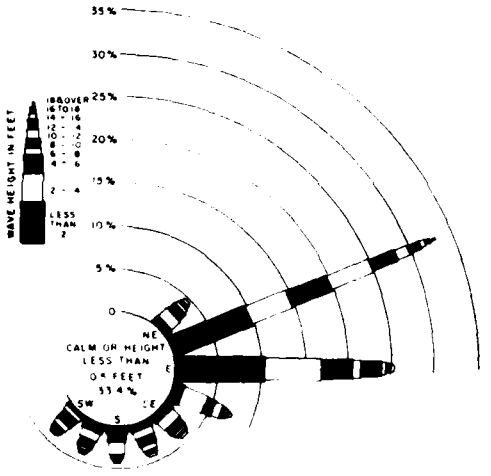

LOCATION MAP
2 0 2 4 6 8
NANTUCKET SOUND
TUCKERNUCK IS.
NORTH PT
EEL PT
SMITH PT
Madaket Harbor
ESTHER ISLAND
JACKSON PT
Little Neck
HITHER CR.
Great
Neck
ATLANTIC OCEAN
1000 0 1000 2000 3000
WATER RESOURCES IMPROVEMENT STUDY
MADAKET HARBOR
NANTUCKET, MASSACHUSETTS
GENERAL MAP

PLATE B-1

COMPOSED OF DATA OBTAINED BY HINDCAST OF 3 YEARS OF WIND RECORDS (1948-1950) SHOWING PERCENT OF TIME WAVES OF DIFFERENT HEIGHT OCCUR FROM EACH DIRECTION FROM BEACH EROSION BOARD TECH MEMO NO 55.



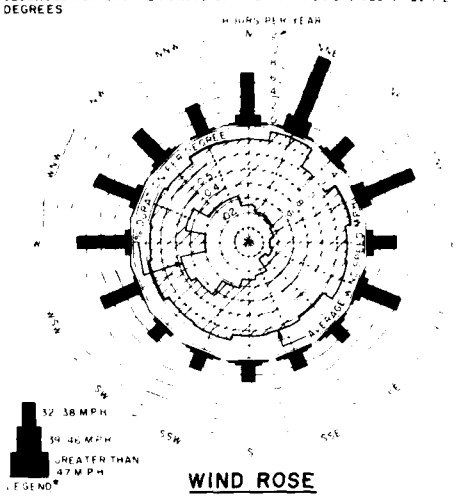
WAVE ROSE

OFF NAUSET BEACH, CAPE COD, MASS.
(LAT. 41° 50' N, LONG. 69° 30' W.)

*DURATION FOR EACH RANGE OF WIND SPEEDS IS MEASURED OUTWARD FROM TOP OF UNDERLYING BAR GRAPH

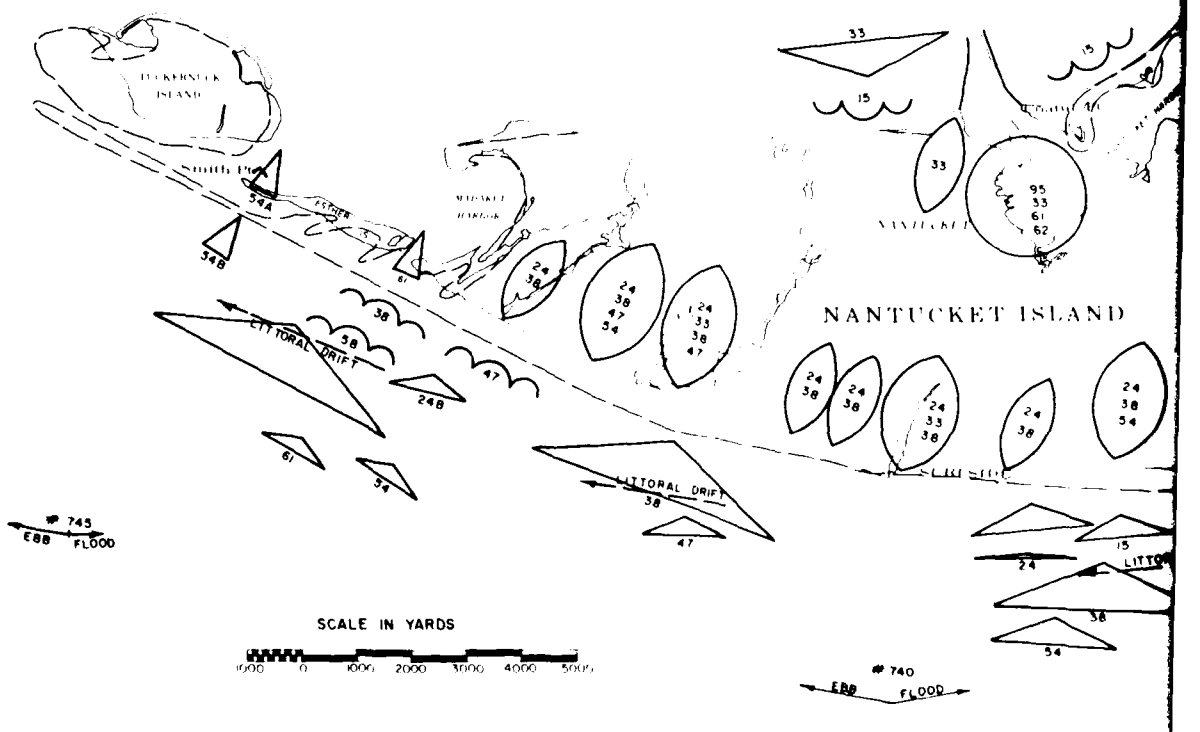
NOTE

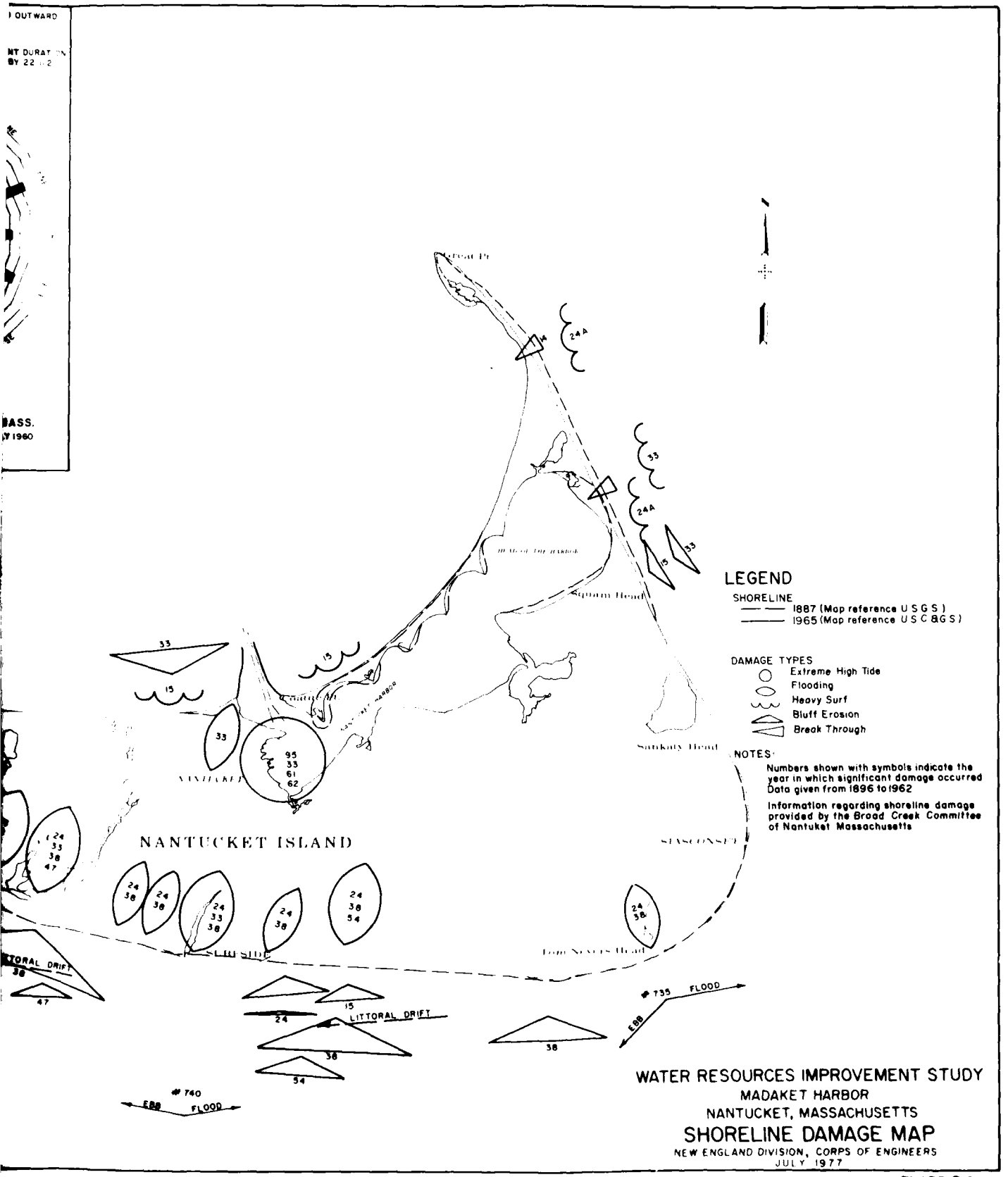
PERCENT DURATION PER DEGREE IS THE AVERAGE PERCENT DURATION OBSERVED FOR EACH 16 POINTS OF THE COMPASS DIVIDED BY 22.5 DEGREES



WIND ROSE

MEMORIAL AIRPORT, NANTUCKET, MASS.
AUGUST 1952-JULY 1957 AUGUST 1958-JULY 1960
AUGUST 196-JULY 1965
11 YEAR RECORD





WATER RESOURCES IMPROVEMENT STUDY

MADAKET HARBOR

NANTUCKET, MASSACHUSETTS

SHORELINE DAMAGE MAP

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

JULY 1977

PLATE B-8

SECTION C

PROBLEMS AND NEEDS

PROBLEMS AND NEEDS

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SECTION C

PROBLEMS AND NEEDS

1. The purpose of this section is to identify, describe, and dimension the problems and needs associated with closure of the Broad Creek breach in Madaket Harbor and the dredging of the harbor bottom. Information is presented relative to the deterioration of this Nantucket water resource since the breach in 1961. Improvements desired by local interests appear at the end of this section.

2. Madaket Harbor has provided Nantucket with an important exportable fish resource satisfying a very real economic need for this island community. It is also an island food resource needed by many residents as a diet supplement. Breaching of the Broad Creek barrier in 1961, and subsequent shoreline erosion, resulted in the destruction of the shellfish beds which were productive in the harbor. Sand shoaling caused by the breach has made harbor navigation hazardous, particularly to Hither Creek. Needed employment afforded by Hither Creek Boat Yard is now threatened due to restricted access by commercial and pleasure craft. The recreational emphasis characterizing area land use is also threatened by unsafe swimming conditions near the breachway and the possibility of excessive storm damage to local properties because of increased exposure to storm activity from the south.

Status of Existing Plans and Improvements

3. With the formation of the Broad Creek Committee, Nantucket residents recognized the seriousness of the deterioration of Madaket Harbor. This committee prepared a report entitled, "On Harbor Dredging and Construction of a Reinforced Sand Jetty at Broad Creek Opening, Madaket Harbor," which was presented to the Board of Selectmen and Finance Committee on June 24, 1970. In conjunction with the release of the report, a public hearing was held on navigation improvements of Madaket Harbor, Nantucket Island, by the Department of the Army, New England Division, Corps of Engineers at 7:40 p.m. at the Nantucket High School. The consensus of the hearing and the committee report indicates that closure of the Broad Creek opening was not only desirable, but also necessary to preserve the harbor water resources.

4. A study and report prepared for the Department of the Army, U.S. Corps of Engineers was completed on June 20, 1973 and entitled, "Study and Report on Closing Breach in Barrier Beach, Madaket Harbor, Nantucket, Massachusetts." This work, by Tibbetts Engineering Corp. of New Bedford, Massachusetts, investigated the technical feasibility of breach closure utilizing dredged material from Madaket Harbor. This report disclosed that a reinforced sand structure could be constructed so that an effective barrier would be reestablished across Broad Creek Opening closing the harbor to the sea from the south. The present study and report extends the prior investigation in considerable detail so that a proper evaluation of environmental, economic benefits and cost factors can be made. No remedial action has been undertaken to alter or close the breach by any agency or local officials. The magnitude of the work needed to be effective is beyond the immediate financial capabilities of Nantucket Island.

The Harbor Deterioration Problem

5. As a direct result of the Broad Creek Opening breach in 1961, approximately 800,000 to 900,000 cubic yards of sandy material has been transported into Madaket Harbor and deposited in a fan shaped configuration over the interior harbor bottom. Approximately 395 acres, or 54% of the interior harbor of 746 acres now has an unstable sandy bottom which is non productive in terms of shellfish propagation The channel from Eel Point to Hither Creek and the boat yard has been shoaled so that passage is essentially restricted to boats drawing 1'6" or less, and the sand encroachment is spreading to the north each year. Harbor access from the west has been closed off by a sand bar, and shoaling between Tuckernuck Island and the end of Smith Point will continue to worsen. The safety of recreational users of harbor waters, including the swimming public, is jeopardized by swift tidal currents flowing through the breach at a rate of about 5 knots. Exposure through the breach to storms have made the harbor waters subject to disturbing wave and water current actions, limiting access to properties on Smith Point and making any human use of the harbor area more hazardous.

6. Shore line recession caused by the breach has been dramatic in the Broad Creek area. Loss of property and successive beach line locations are shown on Plate C-1. Between 1956 and 1961, erosion destroyed one residence and caused ten other summer dwellings to be relocated from the

Need for Preservation of Madaket Fisheries

10. The extensive build up of sand which handicaps the boatman has also adversely affected the supply of shell fish and fin fish. If Madaket Harbor continues to fill with sand, the commercial scalloping industry, upon which many of the island residents rely, will be seriously impaired. As harbor depth decreases the stock of fin fish will also decline, affecting commercial and sport fishing interests.

11. Data obtained by the Broad Creek Committee from local sources indicate that from 1970 to 1973 an average annual scallop catch of 5,150 gallons was landed by thirty-eight boats. From 1966 to 1969, these figures were 10,125 gallons and thirty-four boats; and from 1962 to 1965, 11,475 gallons and thirty-five boats. The declining scallop catch has been offset to some extent by a great increase in price. For example, in 1962 scallops brought $9.00 per gallon of meat. In 1973, the price was $25.00 and has remained near this level to 1976. The local seafood dealers explain that the price increase is largely due to an increase in consumer demand and to a lesser degree by a declining local catch since scallops from other sources sold to mainland markets bring the same competitive price. It is apparent that, based on the scallop fishery alone, a need to preserve the total harbor fisheries is pressing.

Improvement Desired

12. Initially, the total economic, social, and environmental impacts on Nantucket caused by the Broad Creek breach were not immediately felt except by local property owners who lost land and personal belongings to the sea in the hurricane of 1961. As the important scallop fishery, the boatyard business opportunities, and the recreational boating safety declined, the island inhabitants recognized the serious nature of the breach as it affected their well being. Their concern culminated in the formation of the Broad Creek Committee.

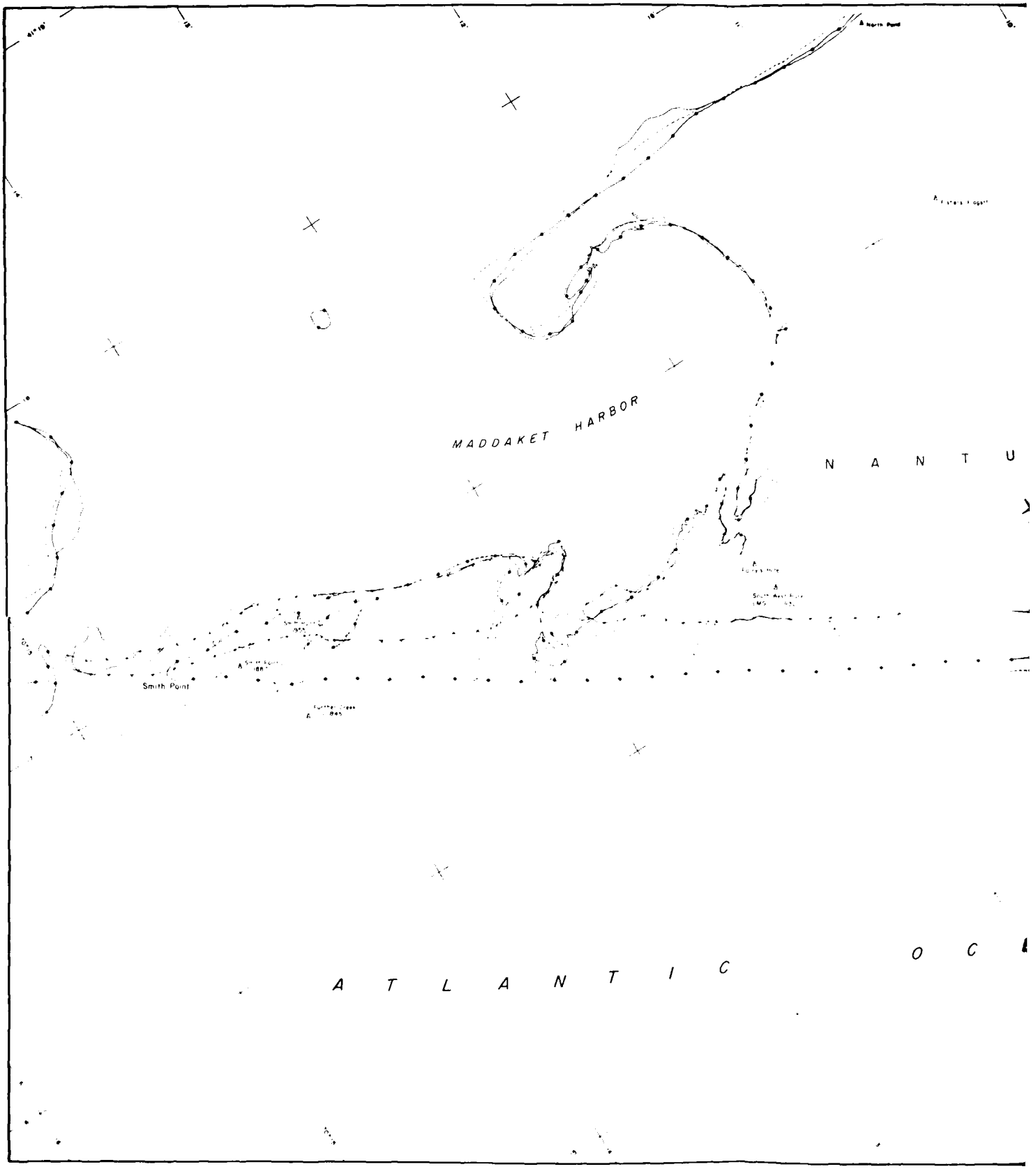
13. The Broad Creek Committee, comprised of seven island residents and appointed by the Board of Selectmen for the purpose of making improvement recommendations in Madaket Harbor, initiated Nantucket's response to the problem. The Committee soon realized that the scope of the problem extended beyond the financial capabilities of the community. Outside

assistance was sought from the Massachusetts Department of Waterways and the Army Corps of Engineers. The Commonwealth responded initially by dredging the main harbor channel in 1965 and reinforcing the western end of Hither Creek estuary with the dredged materials. Continuing sand transport negated the prior channel dredging and a new request was initiated in 1967 for remedial dredging which was completed in 1970. The Committee attempted to monitor the harbor shoaling rate of progress by aerial photographs beginning in April 1967 and, subsequently, through May 1970. See main report for photographs.

14. The Corps of Engineers initiated a study under authority of Section 219 of the Flood Control Act (Title II, Public Law 90-483), approved 13 August 1968. This authority directs a study of Madaket, Smith Point, and Broad Creek, Massachusetts, in the interest of flood control, hurricane protection, navigation, and related purposes.

15. In order that the required navigation survey report may fully cover the matter, a public hearing was held on 24 June 1970 in the auditorium of Nantucket High School. Coincidently, on the same date, the Broad Creek Committee released, "Recommendations on Harbor Dredging and Construction of a Reinforced Sand Jetty at Broad Creek Opening Madaket Harbor," a report recommending solutions to the problem.

16. The public hearing conducted by the Corps of Engineers and attended by eighty-eight Nantucket residents, including the Broad Creek Committee, expressed the public concern for the deteriorating situation at Madaket. Opinions and facts were presented by townspeople from all economic strata concerning the effect the breach has had, or will have, on the island welfare. The Broad Creek Committee recommended that the breach be closed to eliminate hazards to navigation, as well as save the shell fish industry and commercial and recreational boating use of Madaket Harbor. It further recommended that the closure take the form of a jetty filled with sand dredged from the center of the harbor. The proposed jetty will be reinforced with a core resistant to destruction by overwash from hurricanes or severe storms and will be angled so that storm activity from the south or west will wash the outer shore tip of Broad Creek onto the structure. A storm from the north or east will also have a tendency to wash the tip of Meadow Point westerly onto the jetty. Concurrence with the committee recommendations appears to be universal on Nantucket, except for isolated individuals concerned with "tampering with nature."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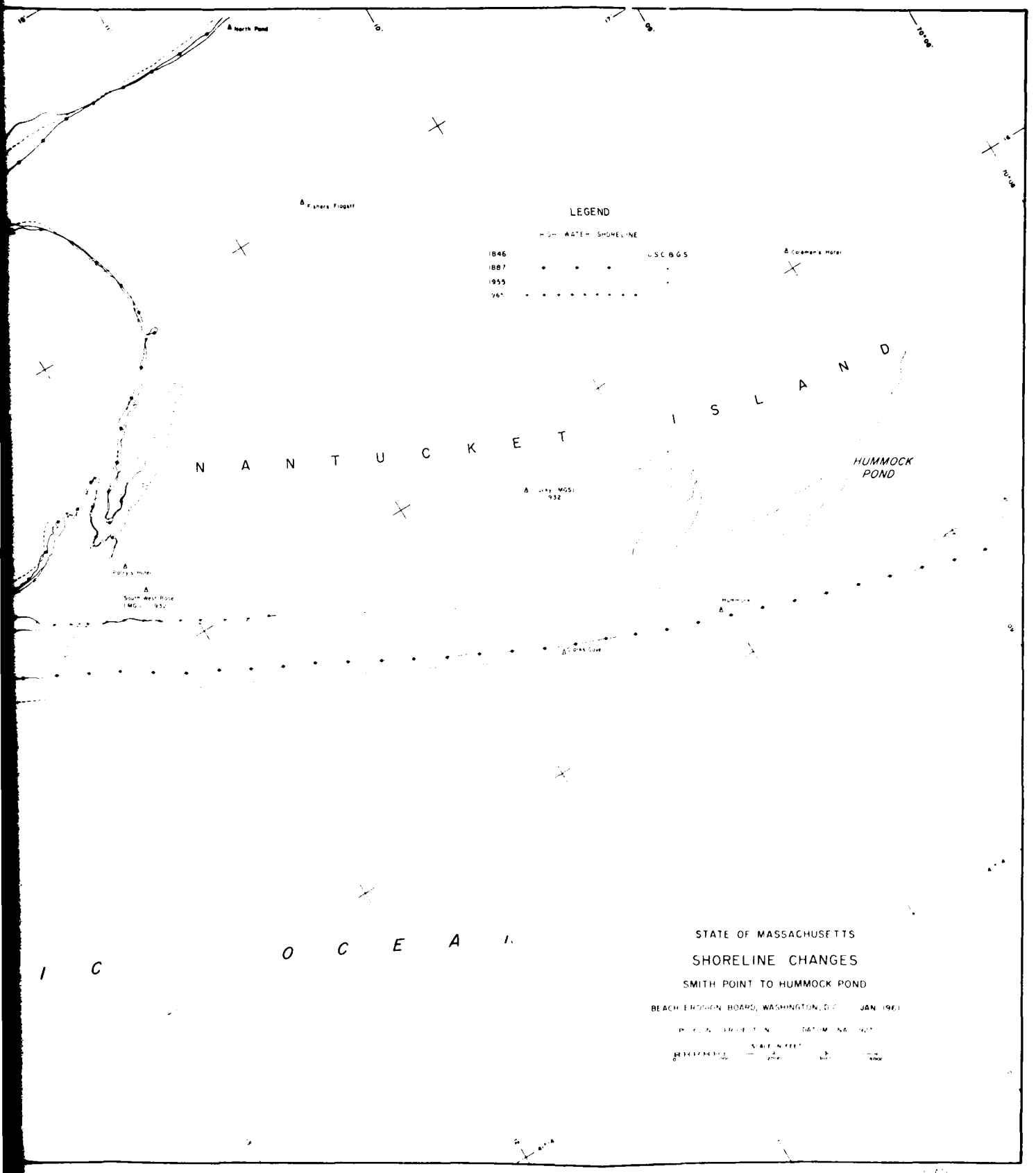
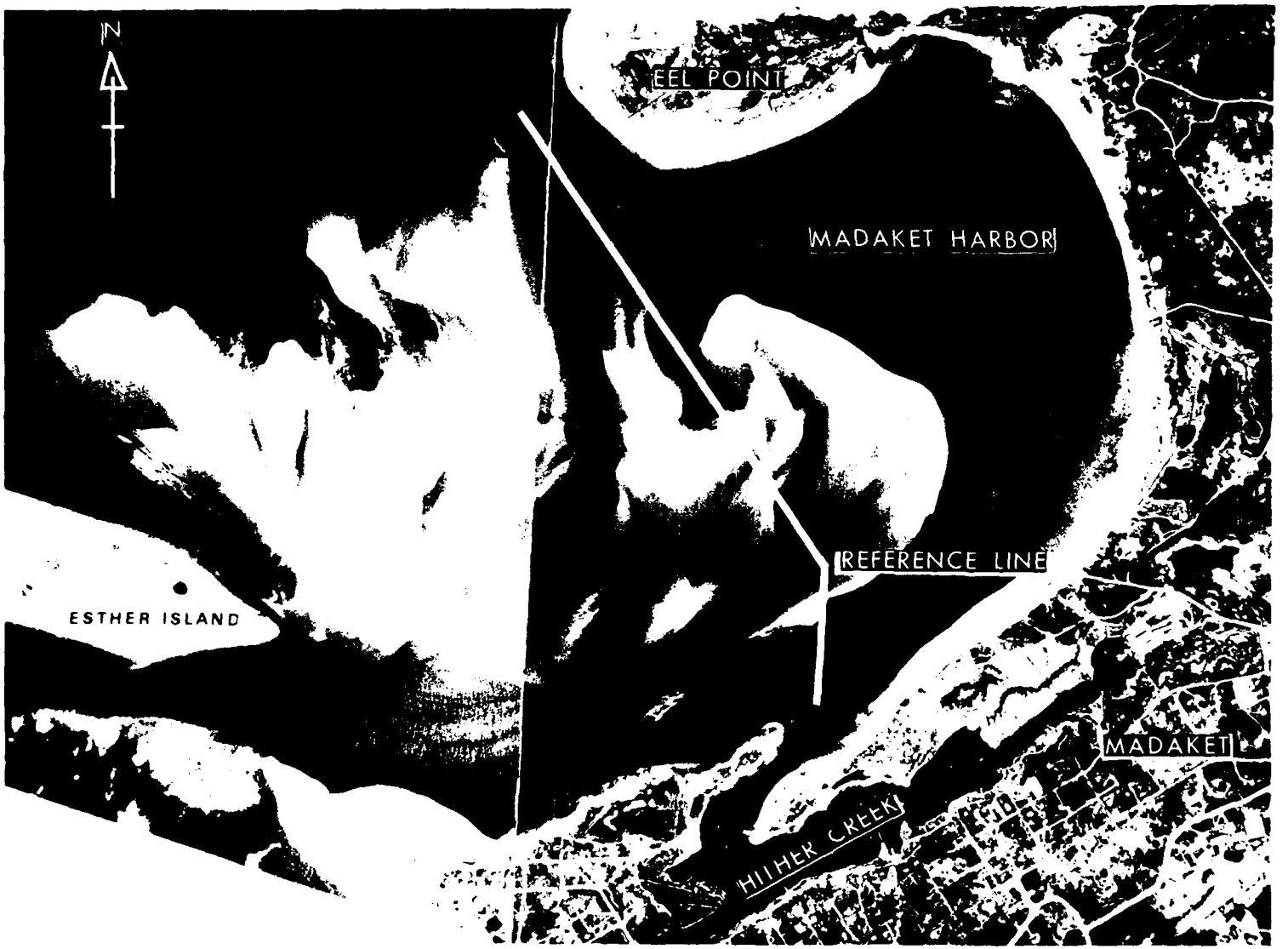


STATE OF MASSACHUSETTS

SHORELINE CHANGES

SMITH POINT TO HUMMOCK POND

BEACH EROSION BOARD, WASHINGTON, D.C. JAN 1961



AERIAL VIEW MADAKET HARBOR, MAY 1974

PLATE C 2

SECTION D

FORMULATING A PLAN

FORMULATING A PLAN

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SECTION D

FORMULATING A PLAN

1. The plan formulation portion of the study explored alternative methods affording solutions to the need for improving the water resources of Madaket Harbor. Each alternative was reviewed considering technical, economic, environmental and social factors.

Formulation and Evaluation Criteria

2. The plan objective is to develop an economically feasible method to restore the shell fish beds and fin fish population in the harbor, to maintain sufficient depth in the navigation channel to Hither Creek which will allow safe vessel passage, and to control shore erosion in the Broad Creek area. An appropriate set of formulation and evaluation criteria are essential to properly review alternative methods and to select a plan which best meets overall objectives. The formulation and evaluation of alternatives was conducted within the context of the Principles and Standards for Water Resources and Related Land Resources.

TECHNICAL CRITERIA

3. The following technical criteria were adopted for plan formulation:

a. The selected plan should be consistent with local and regional land use plans.

b. The selected plan must take into consideration historical data related to water currents and shore erosion in the Broad Creek area of Madaket.

c. Littoral drift patterns in the breachway area should not be disturbed appreciably to avoid additional sand depletion or accretion of beaches and shoreline elsewhere on the south shores of Nantucket.

d. The selected plan must be able to withstand tidal currents and storm activity,not only during implementation, but also in the future over an anticipated 50-year period.

e. Maintenance requirements of the selected plan should be within the economic capabilities of Nantucket, the State or the Federal government.

ECONOMIC CRITERIA

4. The economic criteria which were applied in formulating a plan are as follows:

a. Tangible benefits exceed project economic costs (national economic development).

b. Each separable unit of improvement provides benefits at least equal to its cost.

c. The scope of development is such as to provide the maximum net benefits unless benefits are foregone or additional costs are incurred to serve the environmental quality objective.

d. There is no more economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes which would be precluded from development if the plan were undertaken. This limitation refers only to those alternatives that would be physically displaced or economically precluded if the project were undertaken.

ENVIRONMENTAL CRITERIA

5. The following were considered in formulating a plan:

a. Utilizing available sources of expertise to determine the impact of plan implementation on shell fish, fin fish and other forms of marine life to minimize danger, damage or destruction.

b. Minimizing the irretrievable use of natural resources to effect implementation of a plan.

c. Incorporating measures in the plan to protect, preserve, or enhance environmental quality in the project area.

d. Minimizing near term disruption of project area, human and wildlife habitat by plan implementation.

e. Making activities attracted to the project area after plan implementation compatible with activities of the surrounding area and environmentally acceptable.

f. Coordinating interested Federal and Commonwealth agencies, local groups and individuals through cooperative efforts, conferences, meetings and other acceptable procedures.

SOCIOLOGICAL CRITERIA

6. The following were considered in formulating a plan:

a. Utilizing available sources of expertise to determine the social effects of plan implementation on the human resources of Nantucket including occupation patterns, employment, and quality of life.

b. Minimizing adverse social impacts such as displaced home sites, increased traffic congestion, noise, esthetic values and health.

c. Increasing the opportunities for economic development of the project area and island consistent with the needs and desires of the local population.

Possible Solutions

7. All possible solutions to satisfy the need for improvement of the water resources of Madaket Harbor were investigated. They covered a range of alternative methods for closure of the Broad Creek breach and restoration of the harbor as an economic resource.

CLOSURE BY NATURAL FORCES

8. Dramatic changes in topography, tidal flat, shoal and shoreline configuration in the Madaket area can be caused by storm activity. Several local authorities felt that such an event could close the breach in spite of the fact that the opening has been established for more than twelve years. The sand bar formations off-shore and south of the breach would supply sufficient material for closure if a southwest storm of sufficient intensity occurred. Littoral drift continues to replenish the off-shore bars and, therefore, would provide a renewing supply for additional build-up by future storms from the same quadrant.

9. A review of the historical records clearly indicates, however, that current and wave forces over an extended time progressively deteriorate the south shore of Nantucket, and erode Smith Point. The creation of the breach opening established new forces further detrimental to Smith Point (Esther Island). Evidence also indicates that the breach is widening and that water current forces will continue to erode Esther Island, and the build-up of sand deposits within the Madaket Harbor will continue unless the breach is closed. Analysis of the water currents within the opening indicates that flood and ebb tides are eroding the eastern end of Esther Island as well as the mainland shore. During ebb tide this material is being deposited in sand rips immediately at the south entrance to the breach, and, along with the normal westerly littoral drift, this material becomes available at flood tide for distribution in a northerly direction throughout Madaket Harbor. There is no evidence to indicate that these past and present conditions will be reversed.

STONE AND RIPRAP JETTY SYSTEMS

10. The construction of a stone jetty system to assist natural forces in closing the opening was considered although it was recognized initially that the cost of transporting stone from a source to the project site would be high. Quarries do not exist on Nantucket and the nearest source of suitable high specific gravity stone is the New Bedford area. It is not feasible to deliver stone by water directly to the Broad Creek opening. Insufficient depths exist within Madaket Harbor as well as over the off-shore bar from Nantucket Sound for heavily loaded barges. Tide rise barely exceeds two feet and at least an 8-foot channel dredged over the bar and within Madaket Harbor would be required prior to delivery and placement of the stone creating additional costs chargeable to stone delivery. Shoaling and off-shore wave conditions preclude water delivery from the ocean side.

11. It would be necessary, therefore, to load stone from the New Bedford area on barges and transport it approximately sixty miles to Nantucket Harbor. After off-loading, the material would be hauled approximately seven miles over narrow town roads westerly to the project site. The final 400-feet would traverse beach sand which would have to be stabilized for passage of heavy vehicles. The stone would then have to be stockpiled and rehandled for placement. It is expected that the light duty town roads would be damaged by heavily loaded trucks.

12. There are desirable aspects connected with a jetty of stone construction. Closure of the breach would be accomplished without the requirement for the addition of a sand barrier. Normal littoral and storm wave forces from the ocean side could be expected to assist in the deposition of sand reinforcement and dredged sand from this and any future project within the harbor could be spoiled on the jetty to supplement natural sand accretion along the diked area. Dredging of selected areas within Madaket Harbor to foster restoration of shellfish beds and provide an adequate channel in Hither Creek would be an added item of required work.

SUNKEN SCOWS AT SELECTED POINTS

13. Surplus barges, properly placed and sunk, [illegible] to create natural shoaling and breach closure. [illegible] that obstructions placed outside the breach would [illegible] currents, and create an additional source of sand. [illegible] could be moved to the site via Madaket Harbor [illegible].

and could be sunk in the breach to form the core of a reinforced sand barrier. These barges (which have exceeded useful life) are available periodically. However serious questions of risk and liability were raised in considering towing such craft from the nearest known source at the time (New York City area) to Nantucket. Such barges, even when new, are designed for only river traffic. After condemnation, the risk of towing long distances in open water is great, even after action is taken to prepare the hull. The high risk, technically and economically, involved in attempting this alternative makes recommendation of this method of dike construction not warranted.

NON-REINFORCED SAND BARRIER

14. Direct deposit of sandfill in the breachway, without reinforcement combined with dredging selected areas in Madaket Harbor to provide for restoration of shellfish beds and navigation channels was considered as a method. Several unfavorable aspects of this method were revealed in the investigation.

15. High velocity current conditions, the rip character of the currents, and wave conditions at the project site would produce substantial backwash and undesirable shoaling in Madaket Harbor as a result of direct deposit of sand in the breach without reinforcement. The large size hydraulic dredge required to provide the volume of sand for rapid closure could not presently navigate to the project site from the harbor side. Furthermore, the source of the large amount of sand needed in a limited time would be of necessity from a confined area. Thus, the removal of sand backwashed into the harbor near the breachway and dredging selected areas for shellfish restoration could not be accomplished in the same operation but would be and added item of work and cost. Further, because of the existing shoal areas, the tug tender would have difficulty with satisfactorily placing the large discharge pipes (30" diamter) used in this procedure. Dredging from the off-shore ocean side is even more questionable due to the seaward exposure, lack of accessibility, rip currents and wave character affecting the general safety of the large dredge.

REINFORCED SAND BARRIERS

16. The deposit of sandfill and placement of sheet steel piling as reinforcement was considered. Three types of steel sheet piling systems are feasible alternatives for reinforcement of a dredged sand barrier. These structures would permit a lower visible profile, be resistant to over-wash, and allow economy of construction and material, depending, of course, on the type employed. Rectangular and circular cell configurations and a single sheet and piling core were evaluated, as follows:

a. The Broad Creek Committee of the Town of Nantucket recommended in their June 24, 1970 report that a sand barrier, or dike, or jetty be constructed, reinforced with rectangular steel sheet pile cells. This proposal would provide a stable and substantial core foundation on which to base a sand barrier structure. Further study indicates problem areas in construction methods and cost factors with use of rectangular cells recommended by the Committee. These require precision placement, wall and tie rod reinforcement, and sufficient size for stability. The final breach closure under adverse current, weather and tide conditions inherent at the project site would create severe construction problems. The amount of steel required for the piling and appurtenant materials exceeds the quantities necessary for the circular cell or single pile systems. Construction labor cost is also greater due to more precise control needed for assembly of the cell bracing and supports.

b. Circular sheet pile cells require less steel since they require no wall or tie rod reinforcement, and can be made smaller with the same stability during construction. Placement requires less precision than rectangular cells, since there are fewer problems related to materials control and handling during construction. In both cases, however, final closure would require optimum current, tide and weather conditions.

c. Of the three sheet piling systems considered, the single sheet driven in-line appears to be most economical and practical under proper supervision and control. The reduced material requirements will lessen costs and handling. Less precision is needed during construction since the piles do not have to be driven in an exact line. Although this method provides much less stability during placement, the problem can be solved with job planning. Final closure may be more difficult under this method, but the time required for it is reduced greatly because of the relatively simple structure and small amount of material to be handled under ideal conditions. Total costs are substantially less than for the other two types of reinforced dredged sand barriers. The sandfill on both sides of the reinforcement would be dredged from the harbor areas selected for restoration of shellfish beds and channel improvement.

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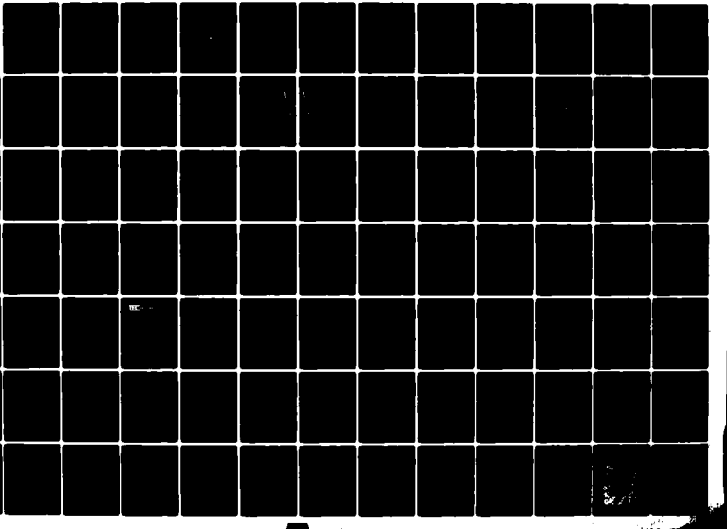

PRECAST CONCRETE STRUCTURES

17. Beach protection methods as well as certain types of jetty and groin systems have successfully used precast concrete structures as a base. Under certain conditions,water and sand permeable configurations when placed parallel to a beach line will accrete sand for the purpose of increasing beach widths. Precast slabs set in a bulkhead along shore, or water jetted in place as a jetty, have been effective as a means to control erosion or to protect harbor and channel openings. However, in the case of Broad Creek breach, the use of precast concrete units was considered to be less feasible than other approaches because of cost and the conclusion that natural forces could not be controlled adequately during placement of the large, heavy slabs required.

WOOD PILING METHODS

18. Traditional approaches to jetty, groin and bulkhead construction in New England have utilized wood piles and sheeting in many instances. The cooler average water temperatures of the region inhibit deterioration caused by marine life. This factor combined with the availability and lower cost of wood make it an attractive material for coastal marine structures. However, placement problems associated with specific gravity and breakage make wood piles more difficult to work with in exposed locations, either above, or in combination with sheeting or with other material systems including old tires. Site conditions preclude the use of wood piling in the Broad Creek Opening when compare to other methods.

SUMMARY OF POSSIBLE SOLUTIONS

19. Seven basic approaches to closure of the breach in Madaket Harbor and restoration of the harbor as an economic resource have been evaluated. The environmental consequences of each are similar insofar as closure of the Broad Creek opening is concerned. Primary impacts on the area concerned with construction activity vary only in degree since all but closure by natural forces involve equipment and human activity on the project site and on local roads. The stone and riprap jetty and the non-reinforced sand barrier alternatives postpone harbor dredging and restoration of the shellfish beds, one of the major project elements necessary to achieve compliance with economic criteria and this element will have to be accomplished as an additional work item. Use of sunken

scows, precast structures, or wood piling to effect breach closure is considered either too difficult or risky to attempt in view of the site conditions and hazards of transporting materials to the site. On the basis of previous discussion, particularly Section C (Problems and Needs), and the comparison of alternatives outlined in this section as related to project technical, economical, environmental and social criteria, the alternative which best satisfies the needs and formulation criteria is a reinforced sand barrier system with a single steel sheet pile core.

Alternatives Considered Further

20. The project requirements to be satisfied are to eliminate or greatly reduce further shoaling of Madaket Harbor and the main navigation channel resulting from transport of sand through the Broad Creek breach, to prevent further destruction of the shellfish beds in the harbor, and to provide methods for restoring the navigation channel and shellfish beds to a useful condition. Project accomplishment by means of natural forces, being extremely unlikely, is now removed from consideration. Closure of the breach between the ocean and Madaket Harbor will eliminate present drastic shoaling of the harbor and channel, and will reduce the future shoaling rate to a normal condition which prevailed prior to the breakthrough in September 1961. Construction of a single sheet piling reinforced sand barrier will satisfy the total requirements and purposes of the project. Restoration of the channel and shellfish bed can be accomplished only by dredging and construction of the reinforced sand barrier will use a sufficient amount of dredged material to meet this requirement. The barrier will be 3,000 feet long in order to provide a proper transition between existing ground elevations on the mainland and Esther Island, with a crest elevation of 11.0 feet above mean low water and dune slopes of 1:15. This design provides a crest elevation having a realistic capability to prevent breakthrough, but will permit occasional overwash not severely detrimental to the reinforced structure. Approximately 650,000 cubic yards of available sand sill be required to complete the barrier, returning about 350 acres of shellfish bed area to production at a minimum depth of 4-feet mean low water and will provide a channel to Hither Creek equivalent to that existing prior to the breakthrough.

21. The construction of a stone jetty will not require sand barrier protection and dredging of the channel and harbor area will be an

additional cost, necessary if restoration of shell fishing is to be achieved. The base cost of a stone structure without sand is considerably higher compared to a sheet pile reinforced sand barrier and, therefore, does not meet project economic criteria. The construction of stone or steel groins along the beach line is not recommended at this time. Construction of additional shoreline erosion control devices or facilities should be the subject of a more extensive study with respect to engineering feasibility, economics and environmental impact for the total protection of the south shores of Nantucket, Smith Point and Tuckernuck Island.

Conclusions

22. A review of the alternatives indicates that a plan formulated on the basis of a single sheet pile reinforced sand barrier for the closure of the breach at Broad Creek, Madaket, most satisfactorily meets the criteria established for the project.

SECTION E

THE SELECTED PLAN

THE SELECTED PLAN

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SECTION E

THE SELECTED PLAN

1. This section presents a description of the project plan selected in the previous section on formulation. Significant information on design, construction, and operation and maintenance is given for the single sheet pile reinforced sand barrier so that the function and interrelationship of its components may be understood. In addition, this barrier system is evaluated with respect to the accomplishment of plan objectives and the salient environmental and social effects it may have on Nantucket Island.

Plan Description

2. The selected plan provides for closure of the Broad Creek opening with a structural system utilizing steel sheet piles, and dredged sand placed on either side of them to form a dike configuration with a centered, hardened core. The closure must also be compatible with the abutting terrain so that storm action will not wash out unreinforced beach areas and weaken the end points. The barrier may be described in terms of its major components.

Functional Elements

3. Effective closure of the Broad Creek breach requires a dike structure 3,000 feet long, approximately 410 feet wide on the mean low water plane, having a crest elevation above mean low water of 11 feet. A side slope gradient on each side, from mean low water to the center crest, of 1:15 will provide reasonable protection from storm wave run-up. A 50-foot wide level section spanning the center portion of the barrier crest will cover the steel sheet piling located on the centerline of the structure. The sheet piling and sand comprise the major material components of the dike and are described as follows:

a. The principal purpose of the sheet piling is to protect the sand barrier from breakthrough by overwash during extreme storm and wave conditions. The individual sheets will be set in line so that bottom penetration is a minimum of 10 feet below existing ground and the top of steel elevation is 10 feet above mean low water. The piles are of "Mariner" steel or equal, with resistance to corrosion of approximately three (3) times standard structural steel alloys. Deterioration of the sheet steel piling over a fifty-year period is expected to be minimal and, in any event, should not affect the usefulness of the structure. Since the piles are interlocked, sand transport through the core will be negligible and the structure does not require precise alignment during placement, a feature which has great importance during the construction phase of the project because of the site conditions. Since the steel will extend to within one foot of the dike crest elevation, it will also provide protection from wind effects on the barrier particularly undesirable erosion.

b. Dredged sand fill from the harbor comprises the primary barrier. Approximately 680,000 cubic yards will be required to close the breach, and provide transition to existing sand beaches at each end. Sand required for the barrier during construction phases involving steel placement and for construction of the total barrier will be obtained by dredging material from the main channel and other selected areas where shell fish bed restoration is desired in Madaket Harbor. This procedure will further stabilize the steel sheet core and provide sufficient material to construct a suitable barrier with the capability to meet project requirements and the severe site conditions related to ocean exposure. Review of current tide and littoral drift data indicates that the area on the ocean side of the restored barrier will be filled in with sand by these forces so that accretion can be expected along the south beach line of the Broad Creek area.

Lands

4. Erosion control for exposed beach surface areas on the barrier and adjacent sections must be instituted and maintained. The prevailing wind direction at the project site is from the southwest at a mean annual speed of 11.5 knots. Maximum speed and direction are 63 knots and southeast respectively, which directly sweeps the open beaches causing sand drift and dune formation. To assist in reducing erosion of the sand barrier from wind effect, beach grass will be planted on the exposed sand as well as on nearby areas lacking vegetation. Every effort must be made to prevent use of wheeled or tracked vehicles after project completion on the dike or adjacent beach areas in order to preserve the designed topographic features of the sand barrier and the end transition sections on the mainland and Smith Point.

Evaluated Accomplishments

5. The selected plan for the improvement of water resources in Madaket Harbor will result in four evaluated accomplishments. They are as follows:

a. Restoration of the shell fish beds and fin fish population in the harbor.

b. Restoration of the main channel to Hither Creek to permit safe navigation to the boat yard and anchorage.

c. Control of shore erosion in the breachway area and shoaling in the harbor interior.

d. Enhancement of the value of the Hither Creek mooring area for recreational and commercial boating and ancillary development.

6. Sand dredging in the harbor to a depth of 4 feet for barrier fill material will restore a minimum of 350 acres to shell fish production. A scallop harvest would be assured under normal conditions by this action. The opportunity for increasing the fin fish catch would be enhanced by virtue of the greater harbor water depth and more favorable eel grass and muddy bottom conditions to permit adequate feeding. At the same time, the improved bottom conditions will benefit lobster and quahog propagation.

7. The main channel to Hither Creek from Eel Point would be deepened to a minimum of 6.0 feet below mean low water. Present conditions prohibit safe navigation for vessels drawing more than 1.5 feet at low tide. The risk of grounding, and resulting damage to hull and power units, is considerable for most types of commercial and recreational boats except for outboard powered craft under 16 feet. While loss of life has not occurred, the potential exists because of the exposed condition of the channel approaches to storm swells from the south through the breachway.

8. Closure of the breach will eliminate breachway shore erosion and prevent transport of sand into the interior harbor. Further loss of property in the Madaket-Smith Point area, particularly on Esther Island near Narrow Creek, will be mitigated by cessation of tidal flow through the breach and sand accretion on the south beaches, which will offset further shoreline recession. Since interior harbor shoaling is caused primarily by sand transported through the breach, closure will halt this process, allowing the bottom to stabilize and eliminate the present need for annual dredging of the main channel.

9. Safe navigational access to Hither Creek will increase the commercial potential of Madaket Harbor. The boatyard will benefit by being in a position to handle more and larger craft, limited now to about 120 boats from 16 to 33 feet long. Gas, oil, dockage and marine supplies sold to local and visiting boats would proportionately increase. Expansion of yard activities into other commercial ventures, such as fish freezing, would become feasible. Local charter boat fishing businesses would find convenient passage from Hither Creek to nearby attractive grounds in the vicinity of the western end of Nantucket and Tuckernuck Islands.

10. One objective of developing shell fisheries in Madaket Harbor is to obtain, consistently, an annual harvest value which will be a significant contribution to the gross value of shell fish exported from Nantucket. The probable return from an unmanaged fishery which relies exclusively on local natural reproduction and recruitment, favorable natural circumstances that minimize mortalities, and neglects the necessity of shell fish bed maintenance has obvious fundamental uncertainties.

Environmental Effects

11. A detailed assessment of the environmental impact of the selected plan appears in Appendix 2. The project objective is to restore the physical beach barrier and harbor waters to their pre-1961 condition. The restoration, consequently, will reestablish an environmental setting which formerly existed in the Madaket Harbor area. This process will be its ultimate primary near term impact. The long term primary and secondary impacts, therefore, become a forecast of what could have developed in the area subsequent to 1961 had the breach not occurred.

12. Immediate effects will result from the initiation of construction activity. Noise and air pollution will be evident from construction equipment, not only in the beach areas near the breach, but also from dredging operations in the harbor and truck traffic on nearby roads. Fumes and noise will disturb wildlife in harbor waters and nearby marsh lands. Background wind and sea noise levels will mask much of the construction uproar, but during calmer periods and at night this activity will be disturbing.

13. Hydraulic dredging operations will create a disturbance in harbor waters. Bottom sediments will be agitated so that increased turbidity will occur in the immediate operational area. This condition could be harmful to marine life by inhibiting feeding and by damaging fish gills. However, the mobile fin fish can easily leave the area during this period. Existing shell fish stocks, although small in quantity will

be affected, and in some cases removed by the dredging. Tidal flow patterns are expected to furnish adequate food for those endermic forms not directly affected by the dredging operation. The sandy composition of the harbor bottom will rapidly settle out of the water column with the cessation of a dredging period. There will be ample time for this to occur during construction at intervals when there will be no dredging.

14. Closure of the breach will provide flood and wave protection to shore line areas within the harbor from southerly storm activity. Harbor waters will be less affected by ocean swells and waves approaching the island from the south. Any localized flooding will tend to be tide generated and not compounded by wave action from the ocean fetch.

15. Deepening of the harbor to 4.0 (MLW) average depth by dredging and the resulting increased water volume may effect the local water temperature variation due to solar heating. Removal of the sand shoals and tidal flats located in central areas of the harbor will reduce the effect of this heat source on surrounding waters resulting in greater thermal stability beneficial to most forms of aquatic life. Since tidal height variation in the area is relatively small (2 feet or less), present and future flushing of the harbor from cooler ocean waters is proportionately modest. (Reference Appendix 3, Marine Research Inc., Madaket Harbor Study).

16. While the selected plan will provide physical protection to harbor waters and enhance the prospects for the restoration of shell fishing as an island resource, increased recreational and commercial use in the long term will disturb wildlife in the shoreline marshes. While human habitation may not increase unduly, transient traffic will change present air, water and acoustic pollutant levels.

Economic Effects

17. The specific economic benefits and effects of the selected plan are described in the following Section F, "Economics of the Selected Plan". There are a number of other economic considerations directly and indirectly attributable to, and resulting from, the project which should be recognized to complete the picture. These items are difficult to quantify and to assign specific dollar values even though they will very likely impact the Nantucket economy in the future.

13. There have been a number of Madaket Harbor and Hither Creek dredging projects accomplished jointly by the Commonwealth of Massachusetts and the Town of Nantucket, beginning in 1936, as follows:

a. January 1936 to September 1936.
State Cost - $2,000.
Town Cost - $4,000.
Scope - Channel from Hither Creek to Eel Point and 200 x 500' mooring basin in Hither Creek.
Quantity of Material - no record. Depth - 4 feet M.L.W.

b. January 31, 1949 to May 1, 1949.
State Cost - $14,378.
Town Cost - $4,792.
Scope - Maintenance and widening of channel from Hither Creek to Eel Point.
Quantity of Material - 13,500 cubic yards. Depth - 6 feet M.L.W.

c. December 29, 1952 to June 30, 1953.
State Cost - $29,760.
Town Cost - $9,920.
Scope - Enlargement of mooring basin in Hither Creek to 200 x 1000'.
Quantity of Material - 43,000 cubic yards. Depth - 5 feet M.L.W.

d. May 5, 1965 to September 16, 1965.
State Cost - $65,679.
Town Cost - $21,900.
Scope - Maintenance dredging of channel from Hither Creek toward Eel Point. This project was first correction of sand infiltration from Broad Creek breach.
Quantity of Material - 63,463 cubic yards. Depth - 8 feet M.L.W.

e. December 1969 to August 1970.
State Cost - $72,065.
Town Cost - $ 25,000.
Scope - Maintenance dredging of channel from Hither Creek to Eel Point.
Quantity of Material - 41,700 cubic yards. Depth - 8 feet M.L.W.

After completion of the 1969-1970 dredging, approximately 25% of the channel, at the mid point, became filled with sand and was not usable. Between 1936 and 1965, maintenance dredging of the main channel to Hither Creek occurred at 12 to 13 year intervals. Since the breach, sand infiltration has required a much higher frequency of dredging. A five year interval

may be needed to provide proper safety at an estimated total cost of between $100,000 to $200,000 per project. Restoration of the barrier should reduce dredging frequency to pre 1961 intervals.

19. Hither Creek Boat Yard, Inc. a corporation owned by local summer residents, provides repair services to wood and fiberglass hulls and to inboard and outboard motors as well as minor rigging on sailboats. From 1966, the number of boats stored and serviced doubled each year to 1970. The present average number is approximately 120 stored and 250 serviced annually. Gross annual business is valued at approximately $250,000. The yard is presently capable of handling boats from 8 feet to 40 feet long. While it would not be reasonable to expect a doubling annual growth rate similar to the 1966 to 1970 period, a 10% rate could be expected, equivalent to an increase in yearly gross business of $25,000, as a result of channel restoration. Less damage to propellers and rudder struts will result in a minor, but welcome loss of revenue to the yard.

20. Time loss of operation for commercial fishing craft will be reduced by a deepened channel and harbor. For example, a new venture, commercial lobstering, commenced in 1974 by associates of the boat yard, is estimated to gross $50,000 per season. However, running light, these boats using Madaket as their port, must enter between one hour before and after high water. An adequate channel to Hither Creek would eliminate this 2½ hour time gate restriction and increase the gross revenue potential of this business by allowing more time flexibility for fishing.

21. A protected, safe harbor would provide tourism benefits with regard to small boat operation and bathing. Madaket's reputation as a "summer resort" area would be enhanced, attracting more visiting recreational boats from Nantucket Harbor as well as mainland ports. Beaches, more attractive and safe for swimming, would have a desired influence on property rentals in the area. Land access to Smith Point would allow more opportunities for sport fishing by local as well as visiting enthusiasts. Property values in Madaket should appreciate at a rate greater than might be expected without the proposed project.

22. The construction of the project will provide payroll and service income to the total Nantucket economy. Housing and food service for contractor personnel as well as other miscellaneous transportation rentals, equipment supplies and repair facilities will benefit directly during the construction period.

Social Effects

23. The proposed breach closure and associated harbor dredging will produce social as well as economic benefits in the area. Although there is some difference of opinion among the persons interviewed as to the priority of, the necessity for, and the feasibility of the proposed project, there is general support for the project if it is not injurious to the surrounding area and can be done well with a minimum of expense to the taxpayers of Nantucket Island. In general, the project is viewed by residents as positive to the economy of the Island and not injurious to either the people or the social/physical environment of either the Madaket area or the total Island.

24. The Madaket area, once looked upon as an isolated locale by the Island inhabitants, can no longer be considered isolated with limited access. There have been, and it appears there will be important increases in the recreational use of land and water, including sport fish fishing. The harbor area is an important arena for commercial shell fishing. The past few years have seen a rather rapid increase in residential land use. Construction has included year-round homes, summer cottages, and an extensive condominium development as the most important change. It was generally agreed by those interviewed that the closing of the breach would enhance or, at least, not detract from land and housing values in the Madaket area, particularly in those areas close to the beach near the project site.

25. The main industry, tourism and recreation, will continue to support directly or indirectly the economy of the area with or without the project. However, without the proposed project it appears that there will be fewer alterntives for employment; that a traditional industry (fishing) will be negatively affected; that only one harbor, Nantucket Harbor, and the resultant business surrounding it will be able to grow and operate effectively; and that boating will be less safe in the Madaket area. It does not appear that the area will be negatively affected in any significant fashion by the closing of the breach. It is true that Esther Island will once again become accessible from the mainland. However, the operation of land vehicles across the dike must be eliminated to protect the integrity of the structure and prevent destruction of planted beach grass.

26. The proposed project could be an important influence in the life of a significant portion of the Nantucket population. Increased shell fishing, one source of employment during the "off-season" (tourist/recreation season), could prove an effective means of helping to reduce the effects of poverty in the population. Furthermore, the project could operate as a morale incentive for many people. The feeling that someone cares about their livelihood could be an important morale boost if the project's positive results for the shell fishermen are emphasized and realized.

Design

27. The proposed plan of improvement is designed to fill in the breach between the mainland Nantucket and Smith Point (Esther Island) in order to prevent littoral drift along the south shores of these islands from transporting through the breach into Madaket Harbor. Under this selected plan, the breach would be closed by a reinforced sand barrier. The resulting dike structure design is based on the most severe storm of record in the vicinity, which is Hurricane Carol of August 31, 1954.

28. The dike or dune profile would consist of two sloping beaches which rise from the sand fill on either side of a core reinforcement to meet with a 50-foot wide horizontal crest. With Hurricane Carol as a design storm, certain beach slopes and a minimum crest height may then be specified for protection. Calculations based on the design storm indicate a crest height of sixteen feet above mean low water and a beach slope of 1:15 on the south side to prevent over topping. The slope on the north side can be steeper to 1:5 because wave action will be less severe. However, since at present the land elevation on each side of the breach is 11.0 feet, and therefore subject to some overtopping, a more practical design consists of a dike crest at elevation 11.0 feet above mean low water and north and south beach slopes of 1:15.

29. The Narragansett Bay Hurricane Survey interim report by the Corps of Engineers shows that tidal flood elevations caused by Hurricane Carol have less than a 2 percent chance of occurring in a given year. The same report indicates that a storm exceeding 11.0 feet elevation can be expected about 5 percent of the time. For practical reasons, therefore, the recommended crest elevation for the dike structure is selected at elevation 11.0 feet above M.L.W. Over topping can be expected about once every 20 years with attendant sand erosion.

30. Savings can be effected by reducing both harbor and ocean side slopes to a minimum since, in general, the flatter the slope the less wave run-up. For example, a dike slope of 1:12 would require a minimum crest elevation of 15.3 feet while that of 1:20, an elevation of 13.6 feet. A flatter slope on the harbor side is required to counteract possible erosion due to wave over topping in the event of a design storm. For practical reasons, again, a dike slope of 1:15 is selected for both ocean and harbor sides of the structure with the assumption that overtopping of the 11.0 feet crest elevation could occur once every 20 years. The parameters adopted for design storm calculations are as follows:

Fetch: F = 100 miles.
Wind: W = 95 maximum.
Wind Direction: Variable from south to southwest.

31. The previous feasibility investigation, dated June 30, 1973 and entitled, "Study and Report on Closing Breach in Barrier Beach, Madaket Harbor, Nantucket, Massachusetts", Appendix A, is included in Appendix 5 of this report and details the design calculations, the results of which have been summarized in this section.

Construction

32. In general, the closing of the breach in the barrier beach would be comprised of a design and construction phase. Completion of these phases would result in closure of the breached area by a sand barrier with a steel sheet pile diaphragm. This construction would restore the breached area, while simultaneously returning Madaket Harbor to a condition equal to or better than that existing prior to the breakthrough. These two phases would require a period of approximately two years for completion.

33. There is no doubt that hostile and adverse conditions would be encountered at the construction site. The land and channel configurations in the breach and harbor area are best described as constantly changing. The site is therefore unique with inherent problems for construction work due to the natural forces encountered at the site. The following paragraphs describe the steps necessary to close the breach. Plate E-1 shows a plan view of the closure structures.

34. The design phase would require that additional field data be obtained. This data would include subsurface exploration, current and flow measurements, and the surveying of land and underwater areas in the breach and harbor area. The field data would be used for design, engineering, updating construction methods, cost estimates, and preparation of plans and specifications.

35. Construction of the closure structure will be described in three phases, preparatory work, stabilization of the breach, and final closure of the breach. Preparatory work would start with the dredging of two channels in Madaket Harbor. Access to the mainland end of the barrier would be via the existing channel from Eel Point

to Hither Creek with an extension branch channel off of this existing channel providing access to an unloading area for stockpiling of construction materials. Access to Esther Island would be via a new spur channel running due south from the present channel between Eel and Smith Points. The channels would be 80 feet wide and 8 feet deep. This work would be accomplished by use of a barge mounted dragline with a four cubic yard capacity and a weekly output of about 10,000 cubic yards of material. This material would be sidecast for later excavation by hydraulic dredge or possibly transported to the dredging stockpile area for dragline pickup and use prior to start of hydraulic dredging. Delivery of materials and the mobilization of equipment for the closure structure would end this phase.

36. With the preparatory work completed construction would start at the mainland end of the barrier. This work would include the placing of about 150 feet of the sheet pile diaphragm, which would end in a transverse sheet pile retaining bulkhead with portions of two standard cells for returns. These part cells would be secured transversely by tie rods and turnbuckles. Overturning would be prevented by securing the piling to a tripod arrangement of batter driven steel "H" piles. This work could be accomplished by use of conventional equipment and methods with backfilling on both sides of the diaphragm done by a bulldozer using material borrowed from nearby areas or material stockpiled from the harbor. The mainland phase of barrier construction would be concluded by placing a mat of heavy riprap (stone) at the base of the transverse bulkhead to prevent scour.

37. The remaining work required to stabilize the breach before final closure would be executed from Esther Island at the west end of the barrier. A considerable portion of this work would best be accomplished by a track mounted crane with a rated capacity of 250 to 300 tons. This crane would preferably be mounted on wide extended type crawlers or possibly be required to work on mats depending on the soil stability. The crane would have a long working radius for sheet piling placement, the required lift capacity for expedient placement of armor stone, and be equipped with a 4 to 6 cubic yard dragline for placing of fill.

38. Material which had been previously dredged from the harbor and stockpiled would be used to build a berm starting from high ground (elev. +11) on Esther Island and extending east towards the breach. A steel piling core would be driven by conventional methods from the west terminus for about 300 feet or into a maximum water depth of ten feet as conditions permit. The type of sheet piling used for this work and the mainland work would be of the straight web type of 3/8 inch thickness and 16 inch width. Backfilling with the stockpiled material on both sides of the piling would be accomplished as work progresses towards the breach.

39. The west barrier would be extended about another 300 feet where a tranverse bulkhead would be constructed. This portion of the diaphragm would be of the arched or "Z" web type sheet piling having a web thickness of one-half inch. This stronger sheeting is required to transmit lateral pressures generated by heavy waves, tide drag, and various water current pressures within the breach. In addition, the greater strength will be beneficial while acting as a cantilever, before equalization by sand placement on both sides of the piling. Upon completion of the west portion of the core and the transverse piling bulkhead a mat of heavy riprap would be placed to prevent scour at the end of the west section.

40. During the time construction is occurring at the east and west ends of the barrier, a hydraulic dredge would be prepared to start excavation in Madaket Harbor. Dredging would start in the northwest area of Madaket Harbor with successive parallel cuts being made in a northeast-southwest direction. The dredged material would first be deposited to an elevation of eight to ten feet above mean low water in the designated dike stockpile location. This material would be used for placement on both sides of the sheet piling as work progress. Mechanical transport in the form of a conveyor system could be used to facilitate placement of the material on both sides of the structure.

41. Final closure of the breach would be executed from the west end of the barrier on Esther Island. A rock closure dike would be constructed from the west end to the east end of the barrier on the ocean side parallel to the center line of the steel sheet piling core. The armor stone would be crane placed in an interlocking arrangement from delivery barges brought into Madaket Harbor. This dike, built to an elevation of 6.0 feet above mean low water, would dissipate wave energy, reduce the currents in the breach substantially, and subsequently aid in retaining the initial sand fill. Once the rock dike is completed the final closure could be made by the driving of Z web type piling to connect the east and west ends of the barrier.

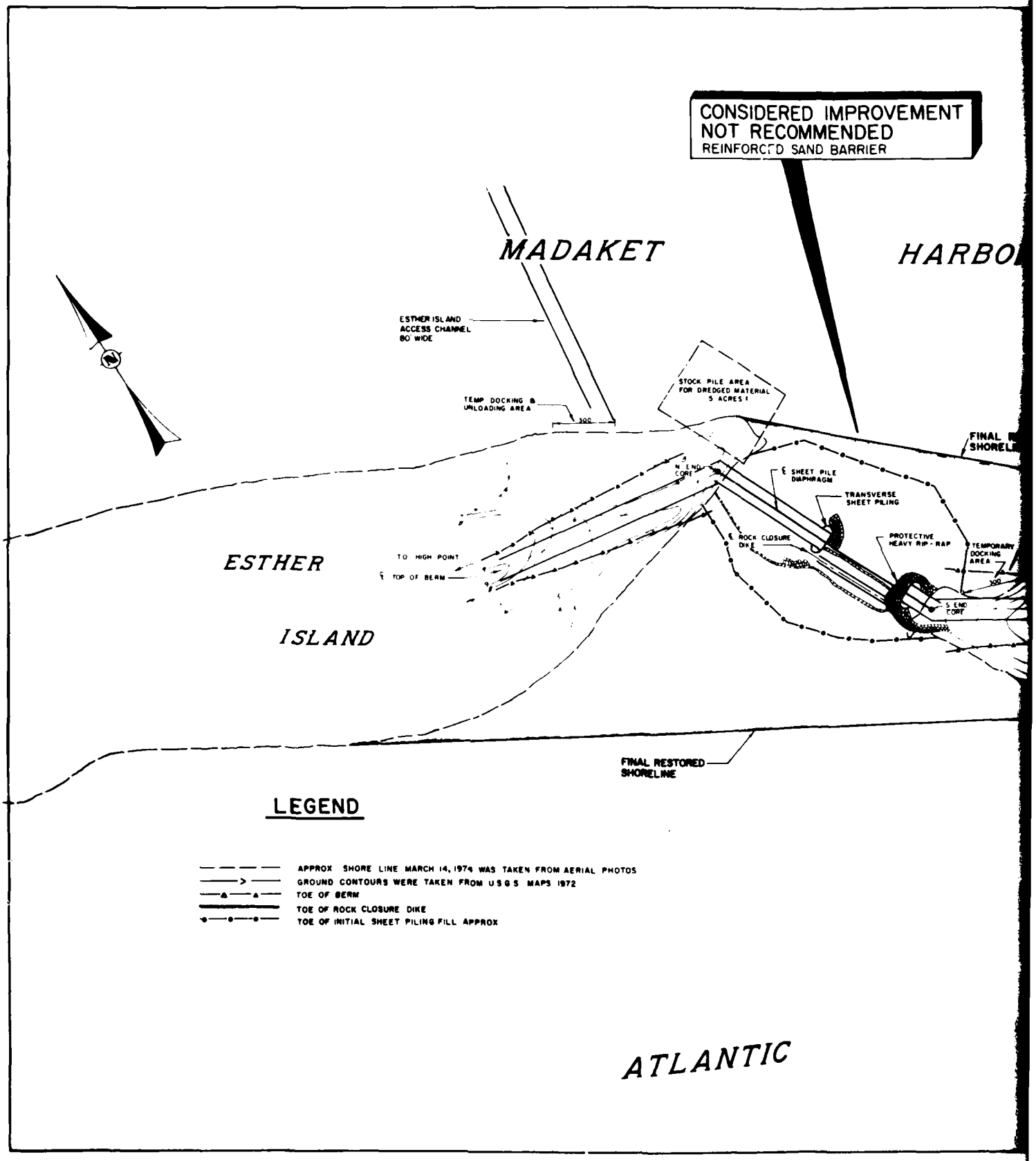
42. Completion of the project would entail the hydraulic dredging of Madaket Harbor to an average depth of four feet below mean low water. The material would be deposited on both sides of the barrier to an elevation of 11 feet above mean low water. This would match the existing ground grade on the mainland and Esther Island. Grading and soil stabilization with the planting of beach grass would complete the reinforced sand barrier. Plate E-2 shows the required dredge areas.

Operation and Maintenance

43. No damage is expected to the steel sheet piling core except for possibly some misalignment. Deterioration of the sheet steel is expected to be minimal and, in any event, should not affect the usefulness of the structure. A Corps of Engineers report entitled, "Durability of Steel Sheet Piling in Shore Structures," dated February 1952, indicates an average rate loss of thickness of .0026 inches per year for standard sheet steel piling when both surfaces are always covered. "Mariner" steel or equal is stated by the manufacturer to have a life three (3) times that of standard steel.

44. Consideration has been given to the final constructed site conditions in relation to existing and expected site conditions in the vicinity of the project over its expected life. It is recognized that any barrier construction may be more stable and resistant to destructive forces than the Smith Point and mainland shores. Therefore, a beach grass maintenance program must include not only the barrier dike, but also adjacent beach areas. Prohibition of wheeled vehicular traffic except on designated roadways must be enforced to avoid destruction of vegetation and the resultant sand erosion from wind and wave run-up. Local interests will be required to provide and maintain public landing and boat launching facilities.

45. Maintenance of the beach fronting the ocean has been considered as a prerequisite to insuring the stability of this beach segment and averting jeopardy to the dike section. Prior design storm data indicates that overtopping from run-up can be expected approximately three times during a 50-year period as a result of hurricane conditions. There is also the possibility of over wash from storm conditions which could occur at least on three occasions during the same period, but with less expected damage. On a yearly basis there are sufficient minor storms and average wave conditions to continually erode the shoreline. Erosion of the shoreline is estimated between 8 and 15 feet per year on an average long time historical basis. To offset the shoreline losses and stabilize this beach segment an estimated 75,000 cubic yards of material is needed as nourishment. This quantity is used for calculating maintenance costs of the project.


CONSIDERED IMPROVEMENT
NOT RECOMMENDED
REINFORCED SAND BARRIER
MADAKET
HARBO
ESTHER ISLAND ACCESS CHANNEL 80 WIDE
TEMP DOCKING & UNLOADING AREA
STOCK PILE AREA FOR DREDGED MATERIAL 5 ACRES ±
N END CORE
℄ SHEET PILE DIAPHRAGM
TRANSVERSE SHEET PILING
℄ ROCK CLOSURE DIKE
PROTECTIVE HEAVY RIP-RAP
TEMPORARY DOCKING AREA
S END CORE
TO HIGH POINT
℄ TOP OF BERM
ESTHER
ISLAND
FINAL RESTORED SHORELINE
LEGEND
APPROX SHORE LINE MARCH 14, 1974 WAS TAKEN FROM AERIAL PHOTOS
GROUND CONTOURS WERE TAKEN FROM U.S.G.S. MAPS 1972
TOE OF BERM
TOE OF ROCK CLOSURE DIKE
TOE OF INITIAL SHEET PILING FILL APPROX
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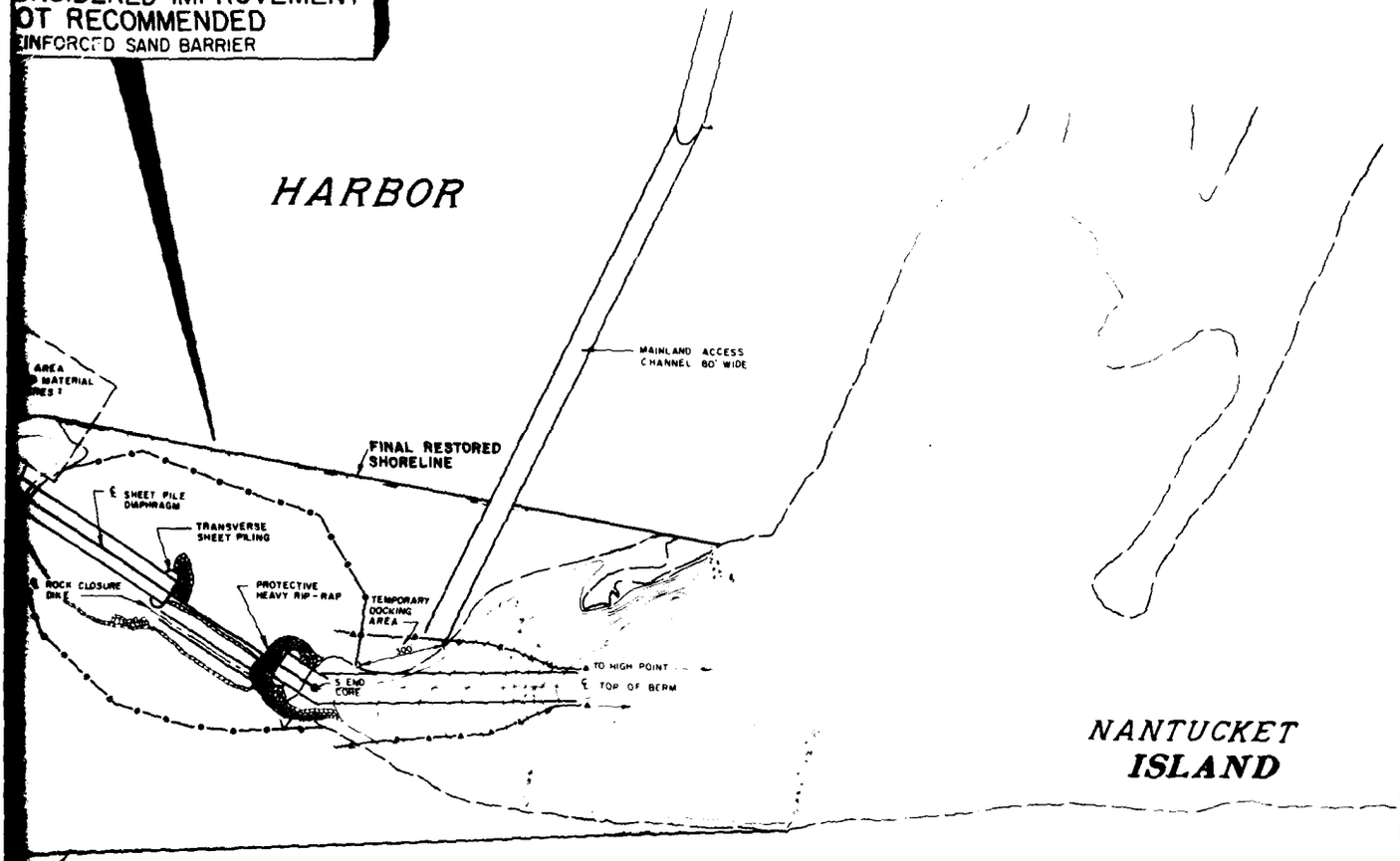
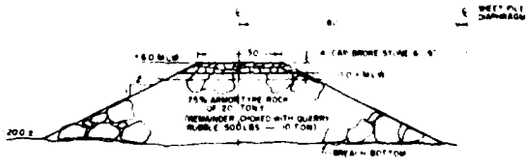




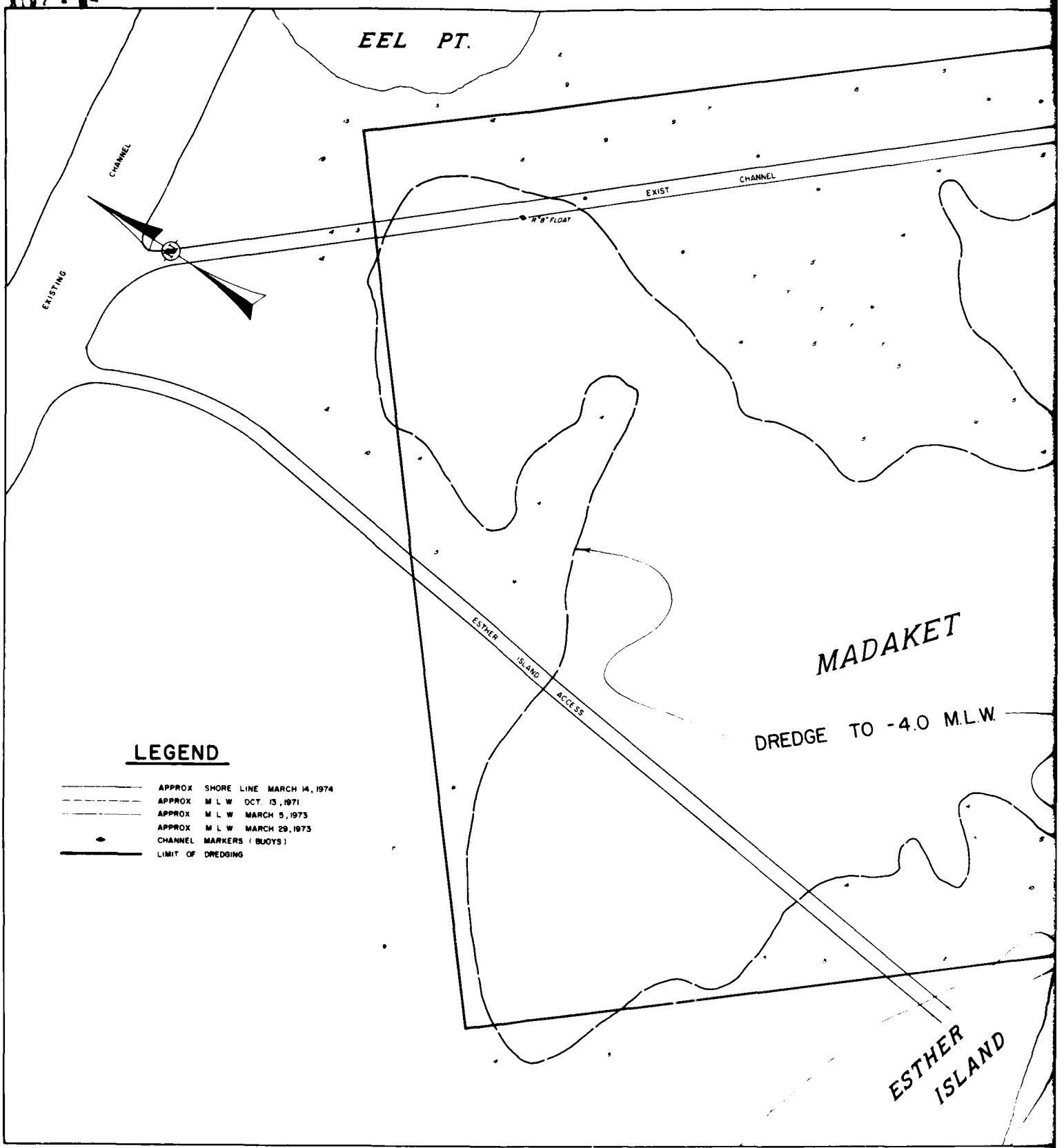
ROCK CLOSURE DIKE
SCALE 1" = 20'

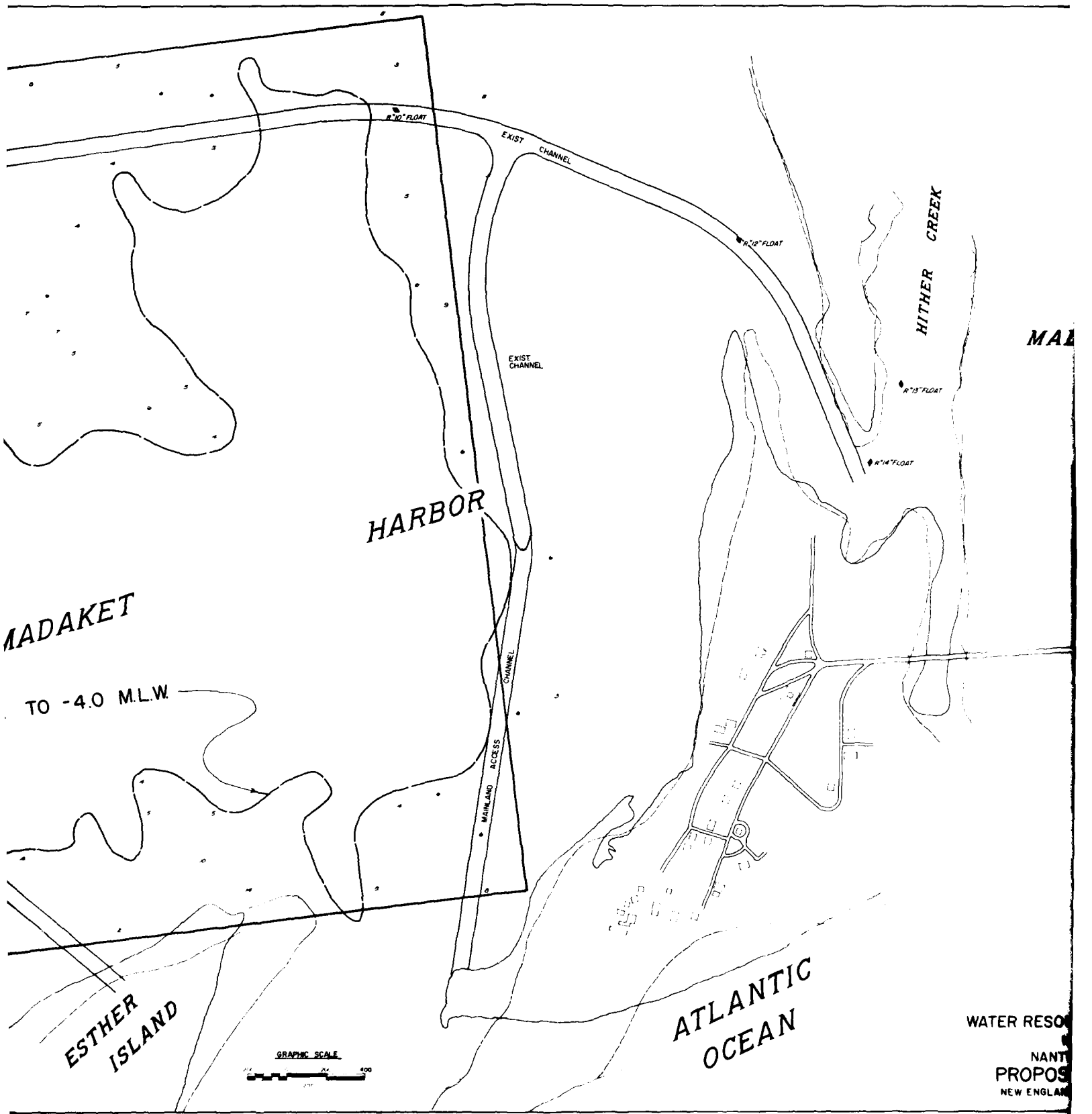
OCEAN

TIC

WATER RESOURCES IMPROVEMENT STUDY
MADAKET HARBOR
NANTUCKET, MASSACHUSETTS
CONSIDERED PLAN
ENG. DIVISION, CORPS OF ENGINEERS
JULY 1977

PLATE E-1


EEL PT.
CHANNEL
EXIST CHANNEL
"8" FLOAT
EXISTING
ESTHER ISLAND ACCESS
MADAKET
DREDGE TO -4.0 M.L.W.
ESTHER ISLAND
LEGEND
APPROX SHORE LINE MARCH 14, 1974
APPROX M L W OCT. 13, 1971
APPROX M L W MARCH 5, 1973
APPROX M L W MARCH 29, 1973
CHANNEL MARKERS (BUOYS)
LIMIT OF DREDGING


R"10" FLOAT
EXIST CHANNEL
R"12" FLOAT
HITHER CREEK
EXIST CHANNEL
R"13" FLOAT
R"14" FLOAT
HARBOR
MADAKET
TO -4.0 M.L.W.
MAINLAND ACCESS CHANNEL
ESTHER ISLAND
GRAPHIC SCALE
ATLANTIC OCEAN
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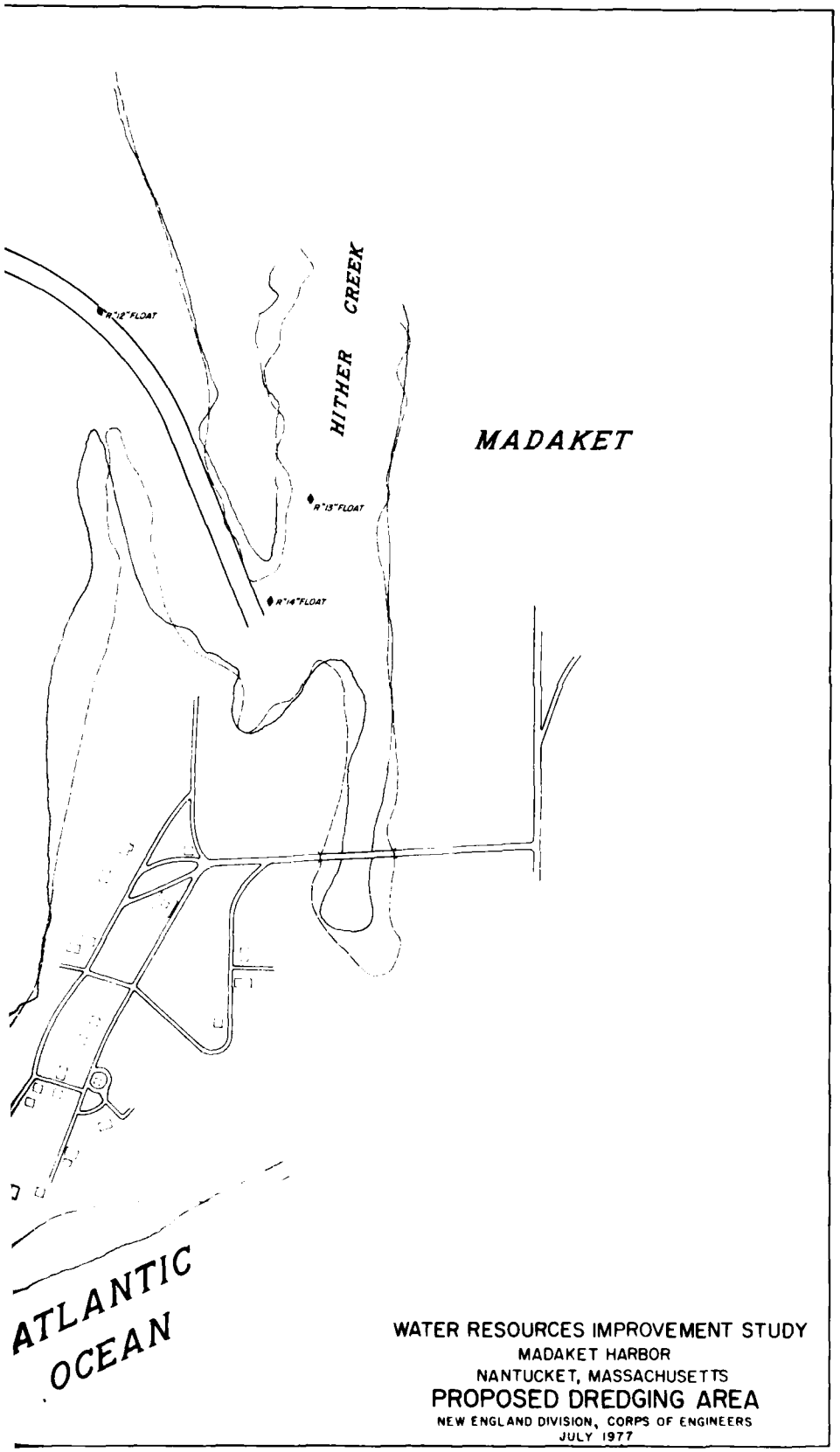
PROPOS
NEW ENGLA



WATER RESOURCES IMPROVEMENT STUDY
MADAKET HARBOR
NANTUCKET, MASSACHUSETTS
PROPOSED DREDGING AREA
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
JULY 1977

PLATE E-2

SECTION F

ECONOMICS OF SELECTED PLAN

ECONOMICS OF SELECTED PLAN

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SECTION F

ECONOMICS OF SELECTED PLAN

1. The economic aspects of the selected plan are presented in this Section of the Appendix. Costs and benefits have been outlined which can be quantified in dollar values.

Methodology

2. The tangible economic justification of the selected plan of harbor improvement can be determined by comparing the equivalent average annual costs such as interest, amortization and maintenance with an estimate of the equivalent average annual benefits which may be realized over a 50-year period. The average annual benefits preferably should equal or exceed the annual costs for Federal contribution toward the project.

3. The value given to benefits and costs at their time of accrual is made comparable by conversion to an equivalent time basis using an appropriate interest rate of 6 3/8% in this analysis. The net effect of converting benefits and costs in this way is to develop equivalent average annual values.

4. A number of economic and physical factors limit the economic life of the proposed project. Examples of these factors include physical depreciation of the adjacent shore line, obsolescence, changing requirements for the project and inaccuracies basic to overly long projections. Based on these factors a project life of 50 years was selected.

5. Development of benefits and costs follows standard Corps of Engineers practice. All goods and services used to develop the project are estimated in dollar values. Benefits are reflected by increased shell fish productivity, savings in channel maintenance dredging and in reduced costs to fishermen caused by the shoaling. Harbor improvement would also increase boating values.

The harbor dredging, in depth and area, is maximized to provide the necessary sand fill required to construct the reinforced sand barrier. A channel depth of 6 feet has been selected to allow the largest practical pleasure or commercial vessels safe passage to adequate moorings or dockage. Savings in channel maintenance are based on more frequent dredging cycles as opposed to the 12 to 13 year intervals required prior to the breach.

Costs

6. The estimated first costs are for the construction of a barrier 3,000 feet long and include the reinforcing material costs as well as the dredging expense to provide the sand fill. In addition, the estimate includes post construction beautification of the areas adjacent to the project site which involves the planting of beach grass.

7. Table F-1 summarizes the estimated first costs for construction of the barrier. Contingency allowances of 15% for dredging and 20% for steel costs have been incorporated. Engineering and supervision have been included at 10% of construction cost as shown. Dredging of the outer bar in Nantucket Sound has been included in the estimate to provide full channel depth into Madaket Harbor from approaches in the Sound. All prices are based on early 1977 costs.

Annual Costs

8. Annual cost estimates appearing in Table F-1 are based on a 50-year project life. Interest during construction is not included since this period should require less than 2 years. Interest and amortization are based on a rate of 6-3/8%. Maintenance of the main channel is based on pre 1961 dredging frequency and barrier repair on the estimated overtopping damage to be sustained from severe storm activity on a 50-year projection of 3 major and 3 minor occurrences.

TABLE F-1

COST ESTIMATE

ITEM	COST IN DOLLARS	
Dredging Harbor, 650,000 c.y.	$2,460,000	
Dredging Outer Bar, 15,000 c.y.	60,000	
Contingencies	380,000	
Subtotal		$2,900,000
Stone Riprap, 55,000 Tons	2,170,000	
Steel, 1,442,000 lbs	460,000	
Contingencies	520,000	
Subtotal		6,050,000
Beach Grass	70,000	
Subtotal		6,120,000
Engineering and Design 4%	250,000	
Supervision and Administration	360,000	
TOTAL COST		$6,730,000

ANNUAL CHARGES

ITEM	ANNUAL CHARGES
Interest and Amortization $6.73 million x 0.06678	$450,000
Maintenance	
Barrier	260,000
Aids to Navigation	5,000
Beach Grass	3,000
Outer Bar	10,000
TOTAL ANNUAL CHARGES	$728,000

Benefits

9. The derivation of benefits resulting from a closure of the breach and harbor dredging for the required sand fill are presented in this section. The benefits evaluated for this study include: restoration of the shellfish resource, reduction of future channel maintenance dredging, elimination of lost time and boat damage, and increased recreational boating values. In addition to these tangible primary benefits, intangible benefits could be realized in the tourism-recreational field to residents of the nearby area.

METHOD OF ANALYSIS

10. Benefits in this report are based on the evaluation of "with" and "without" project conditions. This means the measurement of changes which occur from the present and projected existing conditions as compared to the conditions which could be attained if an action is taken that alters the existing condition. The measurement results can be positive or negative or a combination of both.

11. Evaluation of the shellfish benefits was accomplished with assistance of the following agencies: U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the Massachusetts Division of Marine Fisheries. The resource evaluation is based on information provided in the U.S. Fish and Wildlife conservation and development report which is included in Appendix 5 of this report.

12. Closure of the breach would provide the opportunity for recolonization of approximately 395 acres by scallops and quahogs and the continued use of existing fishing grounds inside the harbor. The harvest predictions have been based on natural production which provide a more accurate reflection of the project values. Values used are reflective of 1976 ex-vessel prices for each species.

13. The investigation of Madaket Harbor's shellfish resources by Marine Research, Inc. suggested the possible establishment of an oyster aquaculture program as a method for increasing the value of species which could be harvested from the harbor (See Appendix 3). A pilot program to obtain valid field data for an [illegible]is was outlined as well as comparisons between the species which could be harvested in Madaket Harbor. There are existing oyster culture programs whereas clam and especially scallop programs are not as developed. The agencies referenced above did consider this analysis,however their final analysis is based on the restoration of the natural conditions for propagation of scallops and quahogs.

14. The projected yields were analyzed using two methods. Method One represents the expected annual gross benefit which can be attributed to the project. This method assumes only a return to pre-breach conditions. Method Two represents the potential annual gross benefit. This represents both the expected benefits of pre-breach conditions plus the potential resource available for harvest dependent on several variables. These variables may include fishing pressure, marketability, available labor, and economic conditions such as cost of other luxury food items. Method Two was used for project formulation.

Tables F-2 and F-3 quantify the dollar benefits.

TABLE F - 2

EXPECTED ANNUAL GROSS BENEFITS

	Bushels Scallop	Bushels Quahog	Value[1] Scallop	Value[1] Quahog
Pre-breach	13,294	1,875	$239,232	$46,875
Post-breach	8,645	1,125	155,610	28,125
Difference (Benefit)	4,649	750	83,682	18,750
			Total Difference (Benefit)	$102,372

[1]Based on late 1976 off-vessel prices of $18/bushel for scallops and $25/bushel for quahogs ($18.00/bu cherrystones, $32.00/bu littlenecks - average value $25.00/bu).

TABLE F - 3

POTENTIAL ANNUAL GROSS BENEFITS

Species	Average[1] Annual Yield (bu/ac)	Total Yield (Total Bu)	Gross[2] Annual Benefit
Bay Scallop	25	9,875	$177,750
Quahog	7	2,765	69,125
Total			$246,875

[1]As determined by the Mass. Division of Marine Fisheries.

[2]Based on late 1976 off-vessel prices of $18.00/bushel for scallops and $25/bushel for quahogs ($18.00/bu for cherrystones, $32.00/bu for littlenecks - average value $25/bu).

15. As can be seen Method Two is much higher than Method One. Method Two represents an upper limit to the range of benefits possible under natural conditions. Method Two also addresses the specific project area while Method One used documented catch of the Madaket fishermen. Thus Method One does not measure the potential changes accurately and was used only as a basis for determining the without condition.

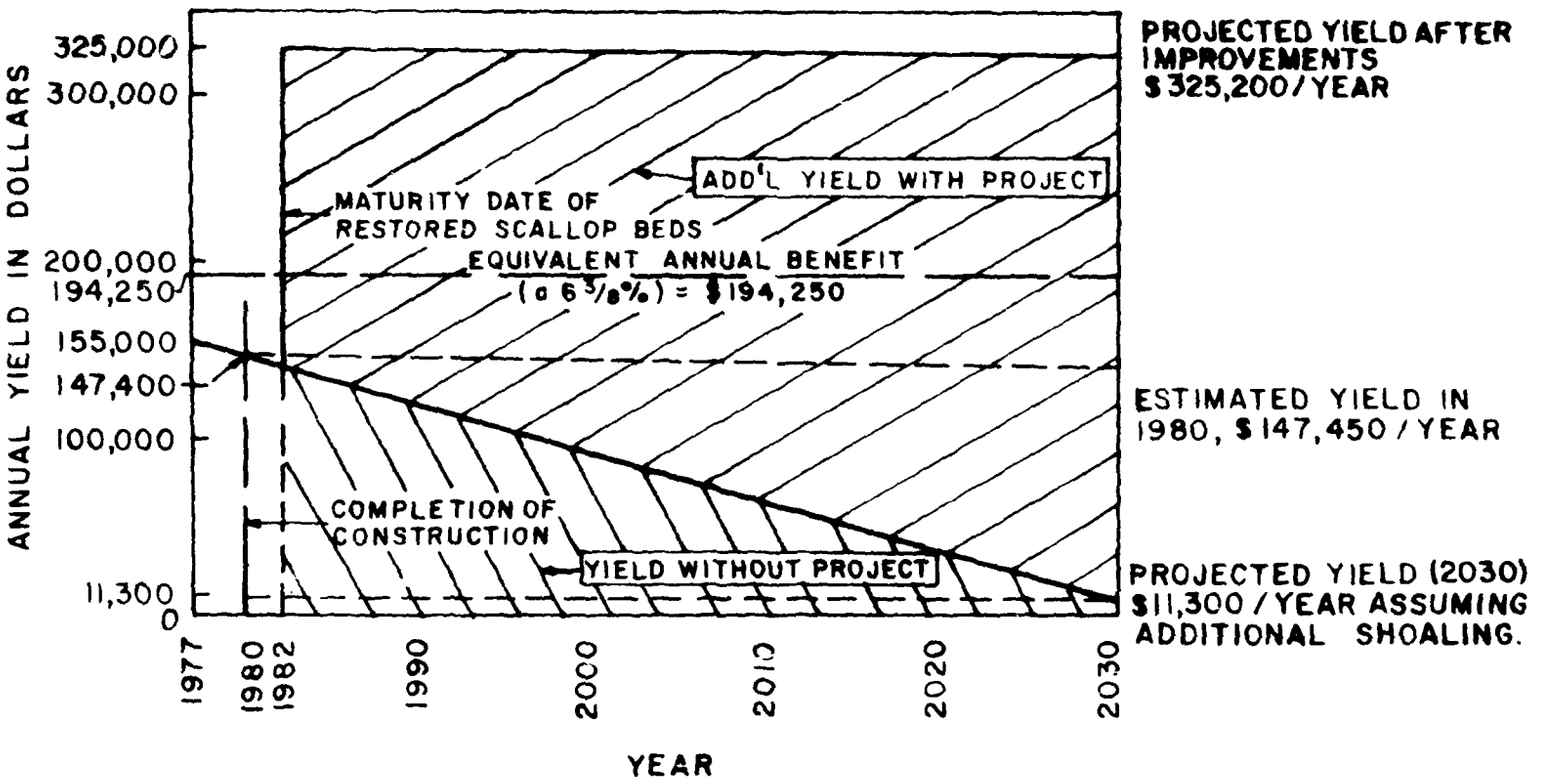
16. Once the harbor is restored, the shellfish resources must be re-established. Immature quahogs would be seeded in the newly dredged areas of the harbor, which must then be allowed to mature and begin reproduction for permanent resource establishment. Recolonization of scallops is expected to be accomplished by migration of existing scallops from adjacent areas. The time frame for the above to occur, before harvesting could begin, is taken at two years for scallops and three years for quahogs. Once quahogs are permanently established it is expected that another three years will pass before full realization of the resource will occur. Graphs F-1 and F-2 depict the above rationale and the relationship of the resource yields to the with and without the project conditions. The resource benefits are the difference between the with and without conditions.

17. To obtain average annual benefits for the shellfish resource, two adjustments must be made to the raw data. The first adjustment is a redistribution of the benefits over the 50-year project life using economic methods. The benefit analysis for scallops assumes continued shoaling and loss of the scallop resource, thus the project would prevent future losses. The quahogs are expected to remain stable as new productive areas replace lost areas. The second adjustment is made after the benefits are distributed over the project life. The benefits can be divided into two categories. One is the cost of acquisition, which includes the fixed and variable costs incurred by the fishermen to obtain a catch. The other is the return to the operator. This return is the net benefit attributable to the project. The net benefit for the fisheries has been estimated at 40% of the average annual gross benefits which have been distributed over the 50 years. The following illustrates the steps in obtaining average annual net benefits.

	Scallop	Quahog
a. Gross Annual Benefits	$177,750	$ 69,125
b. Redistributed Gross Annual Benefits	194,250	53,200
c. Net Average Annual Benefits (40% x b)	78,000	22,000

The total benefits from shellfish resources is estimated to be $100,000.

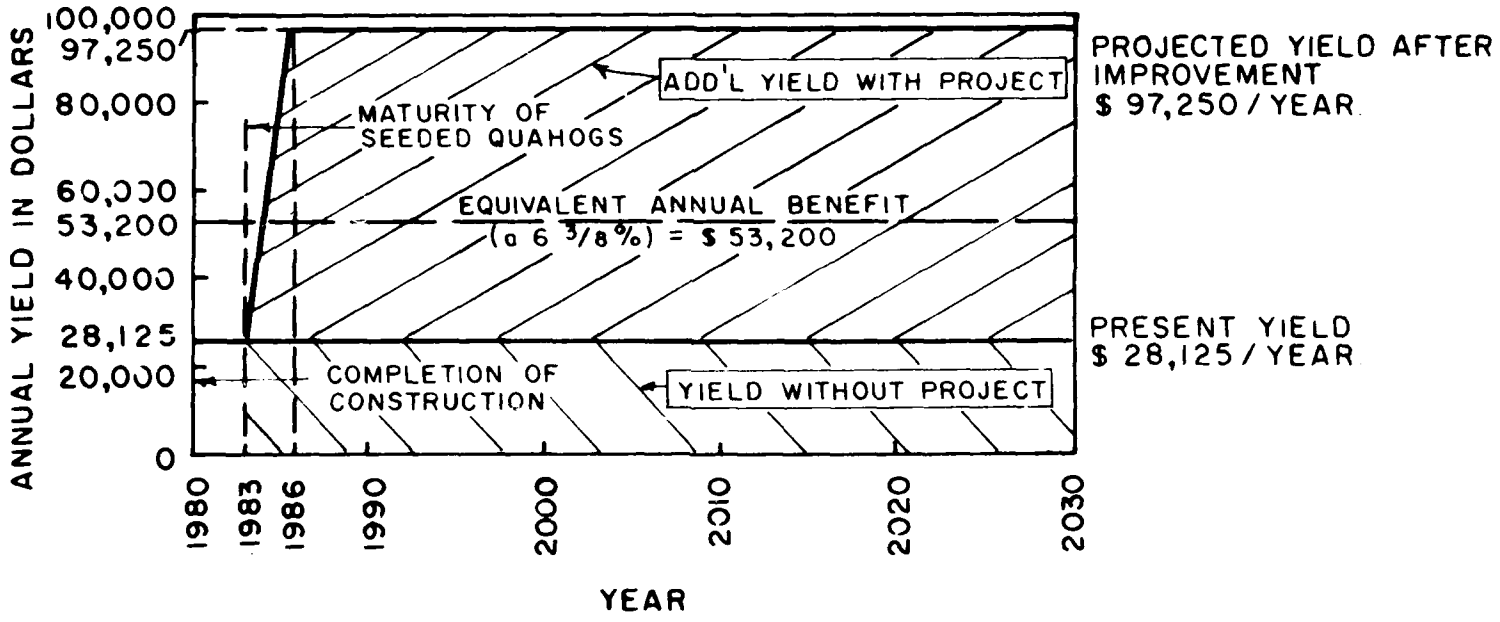
SCALLOP YIELD
MADAKET HARBOR
NANTUCKET, MASS.



Schematic of Benefits for Scallops

FIG. 1

HARD QUAHOGS YIELD
MADAKET HARBOR
NANTUCKET, MASS.



Schematic of Benefits for Quahogs

FIG. F-2

18. The elimination of lost time and boat damage has been estimated using information obtained from local fishermen. These benefits are based on an average season of 22 weeks for fishing, a boat fleet of 39 boats, damage of $150/boat/season, and a lost time value of $3/week/boat. The computations are:

Damage = $150 x 39 = $5,850

Lost Time = $4 x 39 x 22 = $3,432

$9,282 Say $9,000

19. The reduction of future channel maintenance dredging is considered to be a cost that would be eliminated if the project were constructed. Without the closure of the breach the shoaling rate is expected to be 9,000 cubic yards per year. The annual cost is estimated at $32,000 per year. With closure of the breach the shoaling rate is expected to be 3,000 cubic yards per year and cost $10,000 per year. The savings or benefit on an annual basis is $22,000.

20. The future benefits to recreational craft have been computed on the basis of the annual net return to the owners if the boats were "for hire". The net return varies with the type and size of craft, and is expressed in terms of average depreciated value. For this particular harbor the ideal net return varies from 9 percent for the large vessels to 14 percent for the smaller outboards. Benefits would accrue to the existing permanent and transient craft and to boats which constitute growth to the fleet. In the case of the growth boats, the analysis uses a growth rate based on an increasing straight line over the 50-year project life. Tables F-4 thru F-7 show the vessel fleet and the benefits which will accrue with closure of the breach. A summary is as follows:

Recreational Boating Benefits

Item	Amount
Existing Local Fleet	$3,000
Existing Transient Fleet	5,200
Growth of Existing Fleet	1,300
Growth of Transient Fleet	5,000
Total	$14,500

1976 BOATING VALUES

TABLE F4 BENEFITS TO RECREATIONAL BOATING

EXISTING LOCAL FLEET

Boating Season 150 Days

HARBOR: Madaket

TYPE OF CRAFT	LENGTH feet	No. of Boats	DEPRECIATED VALUE Average $	DEPRECIATED VALUE Total $	PERCENT RETURN Ideal	PERCENT RETURN % of Ideal Pres.	PERCENT RETURN % of Ideal Fut.	PERCENT RETURN Gain	VALUE $	ON CRUISE Avg. Days Season	ON CRUISE % of Season	ON CRUISE Value $
RECREATIONAL FLEET		20	3,850	77,000	14	95	100	0.7	539			
		25	5,900	147,500	12	90	100	1.20	1,770			
		3	8,050	24,150	11	90	100	1.10	265			
		35	3,100	62,000	14	95	100	0.7	434			
				310,650					3,008			

Total Benefits = $3,000

TABLE F5 BENEFITS TO RECREATIONAL BOATING

EXISTING TRANSIENT FLEET

Boating Season 150 Days

HARBOR: Madaket

SIZE OF CRAFT Feet	No. Boats	DEPRECIATED VALUE Average $	DEPRECIATED VALUE Total $	PERCENT RETURN Ideal	PERCENT RETURN % of Ideal Pres.	PERCENT RETURN % of Ideal Fut.	PERCENT RETURN Gain	VALUE $	CN CRUISE Avg. Days	CN CRUISE % of Season	CN CRUISE Value $
RECREATIONAL FLEET											
15-20											
21-25	2	5,900	11,800	12	90	100	1.20	142			
15-20											
21-25	10	8,050	80,500	11	90	100	1.10	856			
26-30											
15-20											
21-25	16	12,700	203,200	10	90	100	1.00	2,032			
26-30	4	30,950	123,800	9	90	100	0.90	1,114			
31-35											
36-40											
15-20											
21-25	6	9,900	59,400	11	90	100	1.10	653			
26-30											
31-35											
36-40											
15-20											
21-25	20	3,100	62,000	14	95	100	0.70	434			
26-30											
31-35											
36-40											
TOTAL	58		540,700					5,231			

Total Benefits = $5,200

Appendix F-1

1976 BOATING VALUES

TABLE F6 BENEFITS TO RECREATIONAL BOATING
GROWTH OF EXISTING FLEET

Boating Season 150 Days

MARKET / LENGTH (feet)	# of Boats	DEPRECIATED VALUE Average $	DEPRECIATED VALUE Total $	PERCENT RETURN Ideal	% of Ideal Pres.	% of Ideal Fut.	Gain	VALUE $	ON CRUISE Avg. Days	ON CRUISE % of Season	ON CRUISE Value $
RECREATIONAL FLEET											
[illegible] 15-20	25	3,850	96,250	14	95	100	0.7	673			
[illegible] 21-25	35	5,900	206,500	12	90	100	1.20	2,478			
[illegible] 15-20											
[illegible] 21-25	5	8,050	40,250	11	90	100	1.10	443			
[illegible] 26 & Up											
[illegible] 15-20											
[illegible] 21-30											
[illegible] 31-40											
[illegible] 41-50											
[illegible] 51 & Up											
[illegible] 15-20											
[illegible] 21-30	8	9,900	79,200	11	90	100	1.10	871	40	27	235
[illegible] 31-40											
[illegible] 41 & Up											
[illegible] 5-15											
[illegible] 16-20	30	3,100	93,000	14	95	100	0.70	651	60	40	260
[illegible] 21-25											
[illegible] 26 & Up											
[illegible]	103		$515,200					$5,116			$495

Gross Benefits = $5,116 - $495 = $4,621
Assuming 50 year straight line growth at an interest rate of 6-3/8%,
the average annual equivalent factor = 0.28645
Equivalent Net Benefits = $4,621 x 0.28645 = 1,323

Say $1,300

1976 BOATING VALUES

TABLE F7 BENEFITS TO RECREATIONAL BOATING
GROWTH OF TRANSIENT FLEET

HARBOR: Madaket — Boating Season 150 Days

TYPE OF CRAFT	LENGTH (feet)	# of Boats	DEPRECIATED VALUE Average $	DEPRECIATED VALUE Total $	PERCENT RETURN Ideal	% of Ideal Pres.	% of Ideal Fut.	PERCENT RETURN Gain	VALUE $	ON CRUISE Avg. Days	ON CRUISE % of Season	ON CRUISE Value $
RECREATIONAL FLEET												
Outboards	15-20	20	3,850	77,000	14	95	100	0.07	539			
	21&Up	100	5,900	590,000	12	90	100	1.20	7,080			
Stinkpots	15-20											
	21-25	15	8,050	120,750	11	90	100	1.10	1,328			
	26&Up											
Inboards	15-20											
	21-30	20	12,700	254,000	10	90	100	1.00	2,540			
	31-40	14	30,950	433,300	9	90	100	0.90	3,899			
	41-50											
	51-Up											
Cruising Sailboats	15-20											
	21-30	12	9,900	118,800	11	90	100	1.10	1,306			
	31-40											
	41&Up											
Daysailers	8-15											
	16-20	25	3,100	77,500	14	95	100	0.70	543			
	21-25											
	26&Up											
TOTALS		206		$1,671,350					$17,235			

Gross Benefits = $17,235
Assuming a 50-year straight line growth at an interest rate of 6-3/8%,
the average annual equivalent factor = 0.28645
Equivalent Net Benefits = $17,235 x 0.28645 = $4,936

Say $5,000

SUMMARY OF BENEFITS

21. The benefits as outlined in this section of the report have been developed using applicable standards and procedures which apply to water resources improvements of the Federal government. All tangible benefits have been computed on an annual basis for comparison with costs on the same annual basis. Table F-8 summarizes the annual benefits.

TABLE F - 8

SUMMARY OF ANNUAL BENEFITS[1]

Item	Amount
Scallop Resources	$78,000
Quahog Resources	22,000
Savings in Time and Boat Damage	9,000
Savings in Channel Maintenance	22,000
Recreational Boat Benefits	15,000
Total Annual Benefits	$146,000

[1]Values are Rounded

Justification

22. A comparison of the benefits and costs on an annual basis yields a benefit-cost ratio less than unity as shown below:

Average Annual Benefits	$146,000
Average Annual Costs	$728,000
Economic Ratio Benefits/Costs	0.2

MADAKET HARBOR

NANTUCKET, MASSACHUSETTS

FEASIBILITY REPORT

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ENVIRONMENTAL EFFECT ASSESSMENT

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ENVIRONMENTAL EFFECT ASSESSMENT

MADAKET HARBOR

NANTUCKET, MASSACUSETTS

Project Description

GENERAL

1. The island of Nantucket, located approximately 16 miles from the Massachusetts mainland, extends about 15 miles in an east-west direction and about 10 miles in a north-south orientation at its widest point. It is comprised of 30,114 land acres. Much of the land mass is beach, dune and marsh area, generally situated around the island perimeter. There are, however, three fresh water ponds located in the western interior which do have significance insofar as size is concerned; Long Pond including North Head Long Pond, Hummock Pond and Miacomet Pond. These ponds have a total area of 377 acres.

2. Essentially, two harbors provide water-borne access to the island; Nantucket Harbor and Madaket Harbor. Nantucket Harbor, located on the north central coastal portion of the land mass, is the major commercial center of the island and the site of Nantucket Town. Madaket Harbor, the project site, is positioned at the western extremity and is 5 miles from the Nantucket Harbor ferry wharf.

PURPOSE

3. The proposed project action is directed to the general rehabilitation of Madaket Harbor so that its commercial and navigational value is restored and improved. The harbor area will then, once again, become an aesthetic and economic asset to the island inhabitants, as well as to the substantial number of visitors upon which the insular economy largely depends.

PROJECT ACTION

4. The considered plan of improvement is to construct a 3,000-foot long reinforced sand barrier consisting of sheet piling and sand dredged from the shoal areas within the harbor. The barrier runs from the main-

land on the southerly perimeter of the harbor westerly to Esther Island. This action will close a storm generated breach that occurred in 1961. The breachway has been the source of sand intrusion, the primary cause of harbor shellfish crop destruction and hazardous navigation within the harbor. The construction will replace a prior natural barrier, which afforded storm protection from the south and reduced strong tidal currents in the southerly areas of the harbor.

5. During construction it is anticipated that some disruption of the natural setting will occur. Heavy equipment, such as a pile driver and earth moving machinery, will occupy the beach areas on the southerly perimeter extremity of the harbor. Also, dredging equipment will be positioned at various locations in the harbor with attendant piping, floats and barges. Some truck traffic will occur along Madaket Road between Madaket and Nantucket Town, depending upon the final construction methods selected.

6. In general, the project construction will involve the simultaneous operation of the sheet pile driver, sand moving machinery and the dredge. Pile driving will commence at one or both ends of the proposed barrier on Nantucket and Esther Island. Dredged sand will be pumped from the shoal harbor areas, stockpiled and placed on either side of the sheet steel piling as the steel is placed. This process will continue until the entire breach is closed. Additional sand will be dredged and placed on the restored barrier until the final cross-sectional design dimensions are achieved.

7. Upon completion of the steel reinforced sand barrier structure, the heavy construction equipment will be removed and the finishing work will be completed. This work will involve the placement of beach grass along the barrier at strategic locations to reduce wind movement of the sand as well as the normal clean-up routines necessary to return the site to a natural condition.

8. At this point, unrestricted navigation within the harbor in accordance with existing local, state and federal regulations will be restored. Also, shellfish seeding of the dredged areas can be undertaken to recover this valuable island resource. Finally, full recreational use of the harbor waters and adjacent beach areas will commence.

PROJECT SITE CHARACTERISTICS

9. Madaket Harbor has a water area of about 746 acres within a line between Eel Point and the easterly extremity of Esther Island. Hither Creek, a salt water tributary separated from the harbor by Little Neck, has an area of approximately 25 acres usable for commercial and recreational purposes.

10. The harbor shoreline is 2.84 miles and is comprised of sand tidal flat with the exception of Jackson Point, which is marshy extending to sand flat. Eel Point Marsh borders the tidal flat on the northerly harbor perimeter for a distance of 1 mile with drainage ditching to the harbor.

11. The shore areas around the harbor are sparsely populated except for Jackson Point, south and east of the marsh. The southeast border of Hither Creek is the site of a number of residential dwellings of the Madaket community. The project site beach area east of the breach is not populated at the present time.

12. The project site beach area on the Madaket side is comprised of 13 acres. The total harbor shoreline beach area is approximately 14 acres above mean high water. Assuming closure of the breach and resulting connection to Esther Island, 2.2 miles and approximately 13 acres of beach area would be added to the additional harbor perimeter on the south, making Esther Island and the restored beach area accessible for recreation.

13. Land access to the Madaket Harbor area and the community of Madaket is by public roadway from the east, specifically, Madaket Road, a secondary, hard surface road and the main link to Nantucket town.

14. Alternate access is provided by four essentially unimproved roadways branching from Madaket Road north and west of Trots Swamp. Eel Point Road, starting at Swain Hill, runs west, roughly parallel to Dionis Beach on the north to Eel Point. Barrett Farm Road running southwest to Sheep Pond Road connects with Massasoit Road and Massasoit Bridge over Long Pond. Massasoit Bridge Road runs also southwest to the bridge over Long Pond. Warren Landing Road starts at a small triangle west of North Head Long Pond and runs west to Warren Landing on Madaket Harbor for a distance of about 1 mile.

15. Roadway access to the project site area, beyond Hither Creek, is via Madaket Road south of Jackson Point. Distance from the bridge over the southern extremity of Hither Creek in Madaket to the project site beach area is ½ mile.

16. The breach, extending from the main island to Esther Island, is approximately 1,200 feet wide at the present (1974). Tidal flow through the opening is generally in a northeast-southwest direction on a true bearing orientation at a maximum velocity of five knots. National Ocean Survey Chart No. 265 shows a scoured channel depth of 18 feet at mean low water. This depth was confirmed by Corps of Engineers surveys. Northeast of the breach, inside the harbor proper, the bottom shoals rapidly to a depth of less than 5 feet with tidal flat sandy areas visible 260 yards to the north at mean low water.

17. South of the breach, breakers form over very shallow sand bars. This condition is characteristic of most of the south shore areas of Nantucket, making near shore navigation very hazardous for a distance of from 500 to 1,500 yards offshore.

18. Migrating beach sand characterizes the visible material in the project site area which is devoid of any appreciable vegetation. Topography varies from season to season, largely due to shifting sand dune formations, on the unstable areas lacking beach grass. Project planning includes the planting of additional beach grass to mitigate the beach area sand movement due to storm generated winds.

19. The control of public access by vehicular traffic in the project area will also encourage beach grass propagation. Wheeled traffic is one of the alient factors causing beach grass destruction and the resulting erosion of the sandy shoreline regions. The damage caused by construction vehicles will be repaired and the project area restored to a healthy natural setting. However, control and restraint by the public will be required in the future.

20. The project will include the dredging of the shoaled areas in Madaket Harbor caused by tidal transport of sand through the breach. These shoaled areas encroach a former dredged channel extending from Eel Point to the mouth of Hither Creek and the Madaket community boat mooring area for a distance of ¼ mile. This channel was dredged previously in 1936, 1949, 1965 and 1970 by the Commonwealth of Massachusetts. Aids to navigation have been maintained in the past by the United States Coast Guard in the harbor and channel approaches, extending from red buoy "2EP" on the edge of Tuckernuck Bank to red buoy "14" and blackbuoy "13" located at the mouth of Hither Creek. The project will restore this channel to a minimum mean low water depth of 6.0 feet, which will allow safe access to the harbor landing area. Access at the present time is hazardous, requiring local knowledge over shoaled area for only shallow draft vessels drawing 3 feet or less. Tidal height variation in the harbor is only 1.5 to 2.0 feet under normal conditions. Flood time navigation within the harbor over a route approximating the old channel to Hither Creek provides a maximum water depth of about 4.5 feet.

ESTHER ISLAND

21. Esther Island,named for the hurricane in 1961 which caused the breach, was formerly the westerly terminus of the barrier beach extending from Madaket to Smith Point. It is comprised of duned beach sand with some beach grass vegetation. Several seasonal dwellings are located along the north shore of the island facing Madaket Harbor. Presently, the island is approximately 2 miles long and a maximum of ¼ mile wide. Maximum land elevation is 20 feet.

22. Narrow Creek Pond is located on the easterly end of the island about 100 to 150 yards from the breach. A swampy area extends from the pond 75 yards to the north to sandy tidal flats along the shoreline. A pond area is approximately 1.4 acres.

23. Since separation from Nantucket Island by the breach, erosion of the southerly shore has occurred with great effect along the areas exposed by the breach. All dwellings formerly located between Narrow Creek Pond and the breach have been removed to Nantucket due largely to the danger caused by the receding beach bordering the breach.

THE BREACH

24. Hurricane Esther overtopped the barrier beach on September 20, 1961 on the southern perimeter of Madaket Harbor in an area west of the community of Madaket known as Broad Creek. Storm generated wave action destroyed sparse beach grass vegetation and washed beach sand into the harbor in a northeasterly direction. The breach has expanded to its present width of about 1,200 feet. Maximum depth at mean low water is 18 feet, midway between the main island at Madaket and Esther Island.

25. Maximum tidal generated water speed through the breach exceeds five knots. This condition contributes to the rapid transport and buildup of sand shoals and tidal flats within Madaket Harbor.

26. The cross sectional configuration of the breach is generally prismatic with gentle sloping banks to the center or middle areas. It is estimated that a total of 650,000 cubic yards of sand would be required to close the breach using a reinforced barrier construction method. This volume of sand closely approximates the volume transported to the shoal areas and tidal flats within Madaket Harbor covering the formerly productive shellfish beds.

Environmental Setting Without Project

HUMAN INTRUSION

27. Madaket Harbor, presently, is relatively undisturbed by human activity. Its beach areas are lightly populated with swimmers of all ages, and are used principally for recreational purposes during the summer season. Limited parking in the dune areas nearby restricts vehicular access from other parts of Nantucket. For example, public parking with access to beach areas close to the breach has capacity

for no more than thirty automobiles. Warren's Landing, north of Hither Creek, also provides access by unimproved road with limited parking for recreational beach use and shellfishing.

28. Property owners in the community of Madaket have access by foot to the beaches. Family recreational use, therefore, for swimming, small boat beaching, and shellfishing, appears to be the primary human intrusion on the beaches of Madaket Harbor.

29. Boat use of Madaket is limited by the shoaling generated by the breach. One or two outboard powered craft may be found on harbor waters during a typical fair weather day. Sail boating is restricted by depth to small craft, drawing less than 2.5 feet, except for certain channel areas approaching Hither Creek where up to 4 feet draft may be accommodated at high tide.

30. In areas where sand shoaling is not restrictive to boats, shallow eel grass presents a hazard to free navigation. Fouled propellers and centerboards on sailcraft prohibit operation in all but the deeper channel areas north of Hither Creek and south of the shoal off the Creek entrance to the breach.

31. Hither Creek is the mooring area for approximately forty to fifty boats of all types up to about 23 feet long. Most of this population is tied up at the Hither Creek boatyard docks. Aside from a few shallow draft work boats engaged in commercial fishing, the bulk are pleasure craft owned by Nantucket Island residents. These boats traverse the shoaled harbor channel to offshore waters for fishing and recreational purposes. They do not customarily use the harbor area for any other purpose.

BEACHES

32. The harbor beaches are duned sand extending to shallow tidal flats. They are typical of southern New England with a coarse to fine grain size and beige in color.

33. During winter storms the fines will dune in heavy winds so that plowing is required around many cottages located near the project site. This wind generated drifting is reduced where beach grass has not been disturbed by wheeled vehicles or border marshes exist near Hither Creek.

34. The beaches north of Hither Creek to Eel Point are relatively stable. However, wind drifting does occur in the foreshore areas so that many of the unimproved access roadways require plowing for summer season use.

35. The average tidal beach width varies from 30 to 50 yards, except for areas near the breach. In the breach area, the distance from surviving beach grass to water is about 300 yards of duned and tidal sand. The

shoreline bordering the breach appears to be relatively stable. However, the Esther Island breach line appears less stable with recession occurring particularly during the winter season.

36. The west end of Esther Island (Smith Point) and the southwestern beaches of Tuckernuck Island are subject to marked change over relatively short time periods. For example, over 600 yards of Esther Island disappeared in a four month period during the Spring of 1974. In the same period a beach sand hook rose off the shores of Tuckernuck where about a 3 feet depth of clear water formerly allowed boat passage by Tuckernuck to the southwest. This hook extends south and east of Tuckernuck terminating on a line with Esther Island. Spring storm activity was not intense at any time during the time span of this beach migration.

TIDES AND CURRENTS

37. Average tidal rise and fall in Madaket Harbor is less than 2 feet normally. For this reason, wetted beach surface area is not great as long as offshore or local storm activity is minimal. While the harbor interior is protected from the south and northeast, the exposed nature of the island allows wind driven wave action to develop most often from the southern quadrant. Foot and one half wave heights and 20 to 30 knot winds occur frequently during any season of the year within the harbor.

38. Offshore storms will generate tidal effects superimposed upon the normal rise and fall. Since the fetch to the island is over open ocean, the danger is lessened compared to mainland harbor areas which very often have funnel shaped entrances. However, heavy wave action can continue for days for the same reason since energy attenuation does not occur until the island beach run-up regions are reached. The exposed exterior island beaches receive the total effects of offshore storms while the harbor interior is less susceptible to heavy wave action because of existing barrier beach protection and shallow water depth.

39. Water current action within the harbor is complex. Generally, flows are tide generated and in a northeast-southwest direction in the breach project area. Current speed attains 5 knots maximum through the breachway which accounts for the heavy transport of sand on incoming tides to the harbor shoal areas.

40. Outgoing tides through the breachway encounter sand barrier reefs south of the breach and Esther Island. These reefs appear to be the result of westerly littoral drift along the south coastal beaches of

Nantucket and constitute a renewing supply of sand for transport to the harbor on incoming tides. Since this supply is available, further deepening of the breachway bottom and shoreline is kept to a minimum in the absence of storm generated wave action from the south. Any reversal of sand transport from the shoal areas inside the harbor on outgoing tides is stopped by the sand barrier reefs.

41. All of the above is interacted by an easterly littoral drift along the southwestern beaches of Esther Island (Smith Point) and Tuckernuck Island flowing toward the breachway. This drift reinforces incoming tidal flow to Madaket Harbor through the breach creating a net incoming transport of sand which extends the harbor shoals. In time, it appears that the sand shoals will ultimately cover the entire harbor bottom reducing water depth such that the entire harbor area will become a large sand tidal flat with a few random tidal channels.

42. Current circulation within the harbor alternates direction with tide change. The net effect appears to distribute transported sand primarily from the breachway over the harbor bottom in a fan shaped configuration extending, at present, to Eel Point. The former channel along the north shore perimeter of the harbor is virtually closed for a distance over 500 yards.

SHELLFISH

43. Investigation of the harbor bottom reveals that the shellfish crop has been diminished drastically since 1961 by the sand shoaling. Physical changes of the bottom has made more than half of the harbor area unsuitable for shellfish due to sandy and unstable bottom conditions.

44. Bay scallops (Acquipecten irradians) and hard clams (Mercenaria mercenaria) continue to exist in about 351 acres of productive area. Eel grass growth is generally heavy, however, in these areas.

WILDLIFE

45. The remote geographical location of the Madaket region with respect to the human population center of of Nantucket town, and its insular characteristics make the harbor an excellent refuge for migratory and domestic bird life. Species such as lides, old squaw, scoter, scoup, goldeneye, bufflehead, widgeon, canvasback, mergansers, black duck, mallard, and Canada goose have been observed by island residents.

46. The marsh areas on Eel point and near the entrance to Hither Creek provide protection and feeding for wild fowl. Approximately 170 acres of marsh are available along the harbor shores for this bird population during all seasons of the year. The relatively warm, shallow waters provide a source of small fish food as well.

47. Vegetation in the harbor area is controlled by the local climatology. Scrub pine and beach grass predominate due to the wind velocities and salt spray carried from the beaches and surrounding ocean waters. Deciduous trees do not survive in the Maniaket environment. Therefore, animal life indigenous to a forest setting do not inhabit the project area to any extent.

CLIMATOLOGY

48. Extremes of temperature typical of the New England region are modified by the surrounding ocean waters. They range on the average from a minimum of 24.6 degrees during the winter to a maximum of 74.4 degrees in the summer. The coldest month of the year is February while the warmest is August.

49. Seasonal humidity ranges from 65 percent in April to 89 percent during August. The year around average is 83 percent in early morning and 70 percent at noon.

50. Prevailing winds are from the southwest for most of the year, with occasional dry air movement from the northwest. Storm activity usually develops strong winds from the south or northeast.

51. Rainfall averages 43.66 inches annually. Snow precipitation is relatively light and averages 34.8 inches. Fog is common during the summer-fall seasons creating navigational difficulties for air and water craft attempting access to the island.

POLLUTION

52. Sources of pollution from human activity in the harbor area are few. Since percolation for home disposal systems is excellent in sand, overflows to the harbor are not required for the relatively small number of existing dwellings in the beach areas.

53. Some pollution of bottom sediments in Hither Creek may exist as a heavy metal residue from bottom paints. This has not been determined by analysis.

54. Gasoline and oil spillage occurs infrequently in the Hither Creek boatyard area from boat filling operations. However, this does not appear to be a significant source since traffic is relatively light, in part due to navigational difficulties in the harbor. It should be noted that few boats moored in the creek are live aboard types and that cruising boats seldom visit, again due to access channel shoaling.

55. Sources of air pollution are generally limited to internal combustion engine emissions. Automobiles, dune buggies, and boats contribute to this limited type of pollution. [illegible] from their operation may be disturbing; however, [illegible] is relatively low. Immediate dispersion by prevailing winds [illegible] such that the atmosphere is relatively undisturbed for long periods of time.

56. In summary, the ecosystem in Madaket Harbor maintains a natural balance relatively undisturbed by primary human influences or secondary effects. Its geographical isolation is, in large part, responsible for this situation. Limited access to the area by land or water vehicles protects the environment from commercial development and the very real danger to physical property from storm activity.

Environmental Impact of Proposed Action

57. Project impact may be assessed by reference to the present environmental setting. It should be noted, however, that the project objective is to restore the physical beach barrier to a condition equivalent to its configuration prior to 1961. The restoration, consequently will reestablish an environmental setting which formerly existed in the Madaket Harbor area. This process will be its ultimate primary long term impact. The long term primary and secondary impacts, therefore, become a forecast of what could have developed in the area subsequent to 1961 had the breach not occurred.

PRIMARY IMPACTS - SHORT TERM

58. Immediate effects will result from the initiation of construction activities. Noise and air pollution will be evident from construction equipment, not only in the beach areas near the breach, but also from dredging operations in the harbor and truck traffic on nearby roads. Motive power will be primarily diesel, with possibly as many as ten large motors operating simultaneously for at least ten hours per day for a four to six month period. Dredging very likely will take place on a 24 hour daily basis.

59. Fumes and noise will disturb wildlife in the harbor waters and nearby marsh lands. Background wind and sea noise levels will mask much of the construction uproar, but during calmer periods and at night this activity will be disturbing. Diesel exhaust fumes will disperse rather fast, generally in a northeast direction, over the community of Madaket, Hither Creek and sparsely settled area and beach due to the prevailing southwest winds over the exposed, low-lying terrain.

60. Vehicular traffic over local Madaket roads and roads such as Madaket Road to Nantucket Town will be noticeable. Supplies and equipment for construction will be transported from the ferry piers in Nantucket Town initially to the project site over the local roadways, creating noise, some traffic congestion in Madaket, and inconvenience to residents using local area beaches with regard to road use and parking.

61. Hydraulic dredging operations will create a disturbance in harbor waters. Bottom sediments will be agitated so that increased turbidity will occur in the immediate operational area. This condition could be harmful to marine life by inhibiting feeding and by damaging fish gills. Existing shellfish stocks will be affected and in some removed by the dredging. Navigation will be further restricted by the placement of pipelines from the dredge to either the stockpile areas bordering the breach or to the breachway closure since they will form a physical barrier to passage generally in an east-west direction in the southerly sections of the harbor.

62. As the breach closure [illegible], [illegible] through the remaining opening will increase in speed with greater turbulence affecting shoreline areas bordering the breachway along the southerly extent of Esther Island. Final closure will halt this northeast-southwest tidal flow, with redirection to the north shore of Esther Island and reestablishment of the historic tidal action in the harbor. Since sand transport can occur rapidly in the Smith Point and Tuckernuck Island regions, depending upon storm activity, some changes can be anticipated after breach closure. Induced water currents and tidal circulation will return to pre-[illegible] patterns with main flows on the north between Tuckernuck and [illegible] and on the south between Tuckernuck and Smith Point.

64. Deepening of the harbor [illegible] feet (MLW) average depth by dredging and restoration of the Hither Creek channel will increase total water volume contained within the harbor. This [illegible] will immediately increase navigation within the harbor as the dredging proceeds, allowing safe access by fishing and recreational traffic by the removal of the sand shoals.

[illegible]. Increased water volume within the harbor may [illegible] have a near term effect on the water temperature [illegible] solar heating. Removal of the shallow sand [illegible] located in central areas of the harbor will [illegible] heat source on surrounding waters [illegible] thermal stability beneficial to [illegible] aquatic life. [illegible] variation in the area is relatively small [illegible], present and future flushing of the harbor from [illegible] waters [illegible] the harbor [illegible] proportionately modest. [illegible] Appendix, [illegible], Madaket Harbor [illegible].

66. Land use and management will not be significantly impacted by the project near term. Beach area use for bathing and small boating will continue in the pattern presently evident. Local authorities do not anticipate an major changes in land zoning or building in the Madaket area on the basis of the project completion. In fact, Nantuckers appear to have developed over recent years a restrictive attitude regarding land development on Nantucket as a whole.

67. Closure of the breach will provide flood and wave protection to shoreline areas within the harbor from southerly storm activity near term. Reestablishment of the beach barrier will cause harbor waters to be less affected by ocean swells and waves approaching the island from the south. If localized flooding does occur, it will tend to be tide generated and not compounded by wave action from the ocean fetch. While high winds will cause harbor water turbulence, this energy will be dissipated on the present tidal flats located along the harbor shoreline which will not be dissipated on the present tidal flats located along the harbor shoreline which will not be disturbed by the project dredging.

PRIMARY IMPACTS - LONG TERM

68. Once project construction activity stops, the noise, fumes and associated traffic congestion on local roads in the area will cease. The project area will return gradually to a natural setting and the total harbor environment will become more attractive for recreational human use and wildlife propagation.

69. It is evident that the breachway closure will provide land access to Smith Point (Esther Island). This, in turn, will increase bathing and beach fishing activity in this area. Property owners will no longer have to rely on boat access which is presently hazardous due to harbor shoaling en route from Hither Creek boatyard where their boats are normally moored. There is the potential for dwelling construction (in this area remains stable at its western extremity. However, a wheeled vehicle roadway over the breachway is not considered to be desirable since the project closure must be protected from wind erosion by a firm stand of undisturbed beach grass.

70. As recreational use of the Madaket-Smith Point beach area increases, a heavier traffic volume will utilize local roadways and beach parking areas. Parking facilities and roadway development are limited by the expense of maintaining adequate surfaces for vehicles. Dune Sand pervades the Madaket area, particularly in the beachway region and the adjacent harbor shores. Drifting occurs, particularly during the winter season so that the topography is relatively unstable. Increased congestion may be expected on the narrow unimproved roadways and parking spaces since encroaching sand must be bull-dozed, usually in the spring, to a minimum road width with turnouts for passing.

71. Since the project will provide increased water depth in the harbor, increasing water craft use will occur. Restoration of the Hither Creek channel to Eel Point will allow safe passage for pleasure and small commercial vessels up to about 50 feet in length and 4 to 5 feet draft. The restored sand bottom should provide good holding ground for anchorage in harbor areas other than Hither Creek particularly after general protection from the south is provided by the breachway closure. At present, this type of usage is prohibited entirely by sand shoaling and eel grass. It is possible that pollution of the harbor waters will increase if wastewater discharges by visiting cruising or fisning vessels are allowed. Anchorage areas should be designated by local authorities to avoid disruption of the shellfish beds.

72. Boat traffic in Hither Creek will increase by vessels seeking fuel or other services. It is reasonable to expect also that demand for mooring spaces in the creek will increase bringing additional pollution from oily bilge pumping and heavy metal contamination from bottom paints. Congestion in the narrow creek channel, probably during weekend periods, may be expected and will cause some hazard to young or inexperienced pilots.

73. The project will enhance the prospects for the restoration of shellfishing in Madaket Harbor. Marine Research, Inc. (See Appendix 3) has recommended a program for the island authorities to pursue so that the marketable crop could exceed historical records. The shellfish beds would be seeded and farmed on a controlled basis with area rotation so that overfishing will not destroy or deplete the seedling shellfish growing to maturity. Of course, increased shellfish availability will impact the harbor waters by a proportionate small boat traffic volume in Hither Creek and by trailering to launching beach sites near Warren's Landing and possibly Eel Point.

74. While the project may provide physical protection to harbor waters, increased recreational and commercial use will disturb wildlife in the shoreline marshes. While human habitation may not increase unduly, transient traffic will affect present air, water and acoustic pollutant levels as long term primary impacts.

SECONDARY IMPACTS UPON RESOURCE BASE

75. While the year-round Nantucket Island population unofficially appears to be about 5000 (Reference: Madaket Harbor Water Resources Improvement Study - Sociologists Report - Appendix 4), the summer influx may exceed 16,000. Madaket Community shares this summer growth which is mainly tourist/recreational in character. It should be noted, however, that the Madaket region is considered to be primarily

a summer use region by the inhabitants although some condominium development has occurred along the southern beach areas east of the breach. These are, in part, year-round dwellings.

76. Closure of the breach and the deepening of Madaket Harbor will increase its potential for recreational use. As a result, this region of Nantucket will become more attractive for habitation in the summer season. With an increase in this seasonal population, there will follow demands for more public services such as police and fire protection and utility and waste disposal facilities. Because of a gradual increase in population, the area may lose its isolated character and impose an additional financial burden on the community.

77. Transient summer visitors to the area, attracted by the protected harbor and restored beach areas, will require additional parking space. Present parking in the breachway area and at Warrens Landing will need expansion which may require additional bulldozing of local dune formations to level and stabilize a suitable surface for wheeled vehicles. Rest room facilities may also be required near the parking spaces as a needed convenience.

78. Madaket Boat Yard will require expansion to handle the increase in water craft population utilizing the restored harbor waters. Demand for additional marina spaces will develop which may required additional dredging in Hither Creek. Sewage pump out and disposal facilities will be necessary as larger pleasure craft increasingly use the local waters. Haul out and winter storage activity will increase so that additional land area near the yard will be needed. Convenience services, including ultimately a boatel facility, may develop to accommodate recreational boat demand. The total economic base of the local area will expand with resultant impacts affecting land use and management, pollution control and coastal region wetlands conservation.

79. The shellfish industry on Nantucket will receive impetus to expand as the harbor becomes productive upon project competion. Local inhabitants, as well as licensed transients, will more actively fish the revitalized beds. Local road traffic and parking needs will require additional capacity in addition to that demanded by recreational beach users. Commercial shellfishing, however, will be undertaken largely by local inhabitants of Nantucket as opposed to transient visitors to the island.

80. Some perspective regarding the population size contributing to the impacts resulting from increased commercial shellfishing activity may be obtained from the following Commonwealth of Massachusetts, Division of Employment Security, labor force figures for Nantucket.

	May 1974	June 1974 (Preliminary)	June 1973
Total Nantucket Labor Force	2,530	3,440	3,430
Total Employment	2,460	3,360	3,370
Unemployment Rate	2.8	2.3	1.7

These figures reflect conditions at the start of the so-called summer tourist season. The winter unemployment rate increases to over 12% (Reference: Sociologist Report - Appendix 4) although the labor force is estimated to be between 2,000 to 2,500 persons. While many year-round residents engage in fishing, actual numerical data does not appear to be reliable. Part time fishing activity by residents and visitors will also contribute to the secondary environmental effects previously discussed as the shellfish crop in Madaket Harbor grows in size and value.

81. Regional and national impacts resulting from the project most probably will not be material. While the Madaket Harbor area will very likely grow as a recreational attraction, its individual effect on the entire Cape Cod area is likely to be minimal due to its relative inaccessability. Ferry, pleasure boat and aircraft remain as the primary transportation to Nantucket Island. Auto or bicycle are usually required for land access to the harbor area. While transient pleasure boat traffic will increase locally, the total regional yachting population is not likely to increase as a result of harbor improvements.

MITIGATION OF ADVERSE IMPACTS

82. Many of the negative aspects of the project affecting the environment can be reduced or controlled. Construction activity, a primary impact, can be controlled to reduce water, air and acoustic pollution. This impact will not extend beyond the $1\frac{1}{2}$ - 2 year construction period.

83. The use of a hydraulic suction dredge as opposed to a drag line or bucket dredge will reduce entrained suspended solids in harbor waters. This, in turn, will reduce the gill irritation of finfish.

84. Chemical air pollution can be controlled by emissions regulation of the internal combustion engines used by construction machinery. Properly maintained and adjusted equipment will perform efficiently with a minimum of visible emission of air suspended carbon particulates.

85. Acoustic pollution can also be mitigated by engine mufflers in good condition. Machinery operation can be regulated to result in night time periods of quietness undisturbing to human and wildlife inhabitants in the Madaket area.

86. Dust control on local area roads can be maintained by the limited use of sodium chloride where required by construction vehicle traffic to and from the project side.

87. Increased boat use of harbor waters can be controlled by local regulation as well as enforcement of federal and state laws governing wastewater and oil discharges from water craft. Designation of mooring areas for local and transient vessels can effectively eliminate indiscriminate destruction of shellfish beds by moorings and anchors. Hardened roadways and launching parking sites for trailered boats will avoid beach grass destruction from wheeled vehicles.

88. Long term impacts associated with increased recreationals activity, characterized by more dwelling construction, area beach utilization and a higher population density requiring utility services can be eased by appropriate zoning. Enforcement of building codes, parking regulations and zoning restrictions will control activity by local inhabitants with some loss of personal freedom but with great benefit to the area environment. Present island conservation emphasis should be increased to include long range land use planning, public acquisition of certain beach and marsh areas bordering the harbor, and use of conservation easements from local property owners where possible.

89. The physical change to adjacent shoreline configuration caused by the project construction may have a significant long term impact. Choice of the proposed closure location has taken into consideration the littoral drifts along the south shores of Madaket and Smith Point as well as construction feasibility. It appears from historical shoreline location data that there has been no major change in the westerly direction of sand transport along the south shores of Nantucket, or in the easterly littoral drift west of Smith Point. Intersection of these major transports occurs south of what is now called Esther Island.

90. Since restoration of the barrier beach is the project result, it must be assumed that subsequent beach line changes will gradually occur so that the long term outcome is a local area configuration similar to that which existed prior to 1961. If wind erosion is controlled by a healthy beach grass growth on exposed beach sections to the east or west of the project site, a buildup of sand on shore areas should occur, and southerly storm activity will not overtop or break through the southerly reaches of Smith Point (Esther Island). This action will expand the beach areas on Smith Point and further protect the harbor environment from excessive storm generated wave activity.

91. While some finfish presently use the breach for southerly access to the harbor these habits would revert to pre 1961 conditions. A deeper harbor and uninhibited access from the west and north should mitigate any access closure impact affecting their feeding or circulation routines.

92. Dredging of present sandy harbor bottom sediments and placement upon the breach closure will disturbe the existing harbor area ecosystem, at least until a new shellfish crop is seeded and growing in the dredged areas. A chemical analysis of ocean water and erosion displaced sediment in Madaket Harbor was made in August 1974. (Reference: TABLE.) The analytical results indicate that the material to be dredged is unpolluted in accordance with Section 227.61 (a) and (b), Environmental Protection Agency Criteria for Evaluation of Permit Applications for Ocean Dumping (40 CFR 227; 38 FE 28618, October 15, 1973). Displacement of the sand shoals by dredging to the barrier closure will have a minimum impact upon the harbor ecosystem since:

(a) Dredged material is composed essentially of sand and/or gravel, or of any other naturally occurring sedimentary materials with particle sizes larger than silts or clays, generally found in inlet channels, ocean bars, ocean entrance channels to sounds and estuaries, and other areas of normally high wave energy such as predominate at open coast lines and,

(b) The water quality at and near the dredging site is adequate (according to the applicable State water quality standards for the propagation of fish, shellfish, and wildlife); the biota associated with the material to be dredged are typical of a healthy ecosystem; and with the normal frequency of dredging, the sediments can be reasonably classified as unpolluted.

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August 27, 1974

Job No. E0145

Mr. Richard L. Silviera
Chief Project Supervisor
Tibbetts Engineering Corp.
620 Belleville Avenue
New Bedford, Massachusetts 02745

Dear Mr. Silviera:

On the enclosed laboratory data sheet (page 2) is listed our analytical testing data for each of the sediment and the reference water samples collected in Madaket Harbor by Marine Research, Inc. personnel. The series of tests we performed on each sample was described by Mr. Robert Chase of the United States Environmental Protection Agency to Dr. Tibbetts as being sufficient for the EPA to issue or withhold a permit for the disposal of the sediment in the ocean or on land.

Comparison of test results on the shake test solutions from sediment samples S4226-G and -H with the reference water sample S4226J indicates the sediment to be somewhat dirty sand for which disposal in the ocean or on land should be permitted by the EPA.

Please contact Dr. Tibbetts if you desire any further information on these analyses or any engineering assistance with the interpretation of our analyses.

Very truly yours,

TIBBETTS ENGINEERING CORP.

Fred E. Tibbetts, III, Ph.D.
Director
Analytical Laboratory Division

FET:dmg

CC: None
Enc. Shake Test Analyses Results

Tibbetts Engineering Corp., Analytical Laboratory
Laboratory Certification No. P4871 by Mass. Dept. of Public Health
Water Analyses - (Milligrams Per Liter)

Job No. E0142
Date 8/27/74

Client: Tibbetts Engineering Corp.
Shake Test Samples and Ocean Water Reference Sample.

Source A #15-Erosion displaced sediment bank in Madaket Harbor, Nantucket.
Source B #35-Erosion displaced sediment bank in Madaket Harbor, Nantucket.
Source C
Source D
Source E
Column F Ocean water reference sample collected in Madaket Harbor, Nantucket.

	A	B	C	D	F
Sample No.	S4226G	S4226H			S4226J
Date of Collection	8/14/74	8/14/74			8/14/74
Type of Sample	GRAB	GRAB			GRAB
Collector	Marine Research, Inc.			Marine Research, Inc.	
Date Received	8/14/74	8/14/74			8/14/74
Phosphates as P(Total)	0.53	0.49			0.00
Oil and Grease [1]	11.7	12.8			13.0
Nitrite as N					
Nitrate as N	0.0	0.0			0.0
Arsenic					
Mercury	0.0088	0.0068			0.0088
Nickel					
Zinc	0.022	0.019			0.017
Lead	0.03	0.14			0.06
Copper					
Chromium					
Cadmium	<0.003	<0.003			<0.003
COD	760	770			640

Remarks: See Page 1 for remarks on the above analysis.

Fred E. Tibbetts, III, Lab. Director
Analytical Laboratory Certification

Unavoidable Adverse Impacts

93. Construction activity will produce some unavoidable primary near term impacts. The physical presence of machinery and the associated human activity will be disturbing to the present ambient environment. Noise, dust on roadways, prohibited access by the public in the project area, and disturbance of harbor waters will develop some unavoidable dislocations until the area is restored and the project completed.

94. Long term consequences of a permanent barrier structure are based on the fact that a man-made alteration to a natural physical change has been made. A precise forecast of the effect of this structure on the future shoreline configuration along the south shores of Smith Point and Tuckernuck Island cannot be accurately drawn. This in itself is an unavoidable environmental impact. However, this condition pertains without the project structure although certain long range harbor shoaling and beach loss trends have become apparent since the breach in 1961. Regardless of the breach closure method selected, it is difficult to predict exactly how the littoral drifts will react with sand deposits or at what rate. Much will depend on the frequency and intensity of heavy storm or hurricane activity. The Madaket Harbor area is subject to rapid changes in beach and shoal topography as indicated by the loss of over 2000 feet of the western end of Smith Point in a matter of less than 6 months. The project will inhibit sand transport into the interior harbor which will have a desirable impact with respect to shellfish propagation and local naviation.

95. Recreational activity growth and increasing boat use will increase pollution levels of the bottom sediments in the harbor and particularly in Hither Creek. Accumulated oils and greases, heavy metals from excreting boat bottom paints, debris lost overboard, and other miscellaneous pollutants will be apparent and unavoidable.

96. As the shellfish crop increases and propagates, marine life predators will infiltrate the harbor. Starfish, borers, etc. are attracted by the desirable species of marketable shellfish, i.e., oysters, scallops, etc. Only by artificial "farming" methods can the destruction of marketable shellfish resulting from the intrusion of predator marine life by minimized. A new balance in this element of the present natural ecosystem will be unavoidably affected by the project.

97. Additional unavoidable secondary impacts will occur relative to the increasing utility services required by increased utilization of the improved harbor. A heavier sewage loading on local area ground disposal facilities will be developed by rest rooms, new dwellings and sewage pump out equipment for larger boats. Also, fresh water supply demand will grow in proportion to the growth in local area population including transients. A precise forecast of this demand is not within the scope of this assessment but the unavoidable pressure basis for it is apparent.

Alternatives to the Proposed Action

98. Evaluation of alternative approaches to accomplish project objectives included different structural systems, alternate barrier or jetty location as well as no action of any kind. Environmental considerations and construction feasibility were primary factors. Cost elements were considered to be basically equivalent except for, of course, the no action alternative.

STONE BARRIER

99. A stone jetty or barrier, placed in the same location as the proposed reinforced sand barrier, appeared to be structurally feasible. A stone core faced with armor stone on the north and south exposures has advantage of durability, and, to a degree, structural simplicity. It would provide the base for a solid accessway to Smith Point, and would be less sensitive to the effects of wind erosion and traffic.

100. The environmental consequences of this structural system have both near and long term implications. Overland transport to the project site of large stone weighing several tons apiece would require hauling heavy equipment over existing roads from Nantucket Town to Madaket for a period of six months or longer. The present shoaling on either side of the breach does not permit barge access from the north or south. Construction noise and traffic on the island would exceed levels generated by that required for the proposed sandy barrier structure.

101. Aesthetically, the stone barrier would not blend with the local project setting. It would appear as a human intrusion in an area that should be preserved as far as possible in natural form.

102. Since this barrier structure would not require dredging, the present harbor bottom would not be altered by the closure part of the project. Present limited shellfishing would prevail until storm activity from either the north or west changed the existing shoal formations within the harbor. Shifting of bottom topography without sand removal would not necessarily increase Madaket shellfishing potential from present levels. Since the stone barrier would effectively provide the same breach closure as the proposed project, its effects on the littoral drift on the south shores of Smith Point would be the same.

OFFSHORE JETTIES

103. An early project [illegible] natural breach [illegible] offshore jetties

on the south beaches of Madaket and Smith Point. In effect, this approach would alter current flow through the breach so that littoral drift sand transport would be interrupted in the breach section such that increased accumulation would occur across the mouth of the opening to the south. Some sand bar formation exists in the region several hundred yards offshore at present, caused by intersecting drifts from the east and west, south of Smith Point.

104. Hardened jetties of stone or other materials would be required to withstand the normal and storm wave action. These artifical structures would intrude on the natural setting and would be subject to continual maintenance in their exposed locations.

105. Placement of the jetties would require long term model study to evaluate not only the rate of sand accumulation and its effect upon the breach, but also to ascertain the effects on other beach areas to east and west. The rapid changes of beach and tidal flat topography, particularly evident between Smith Point and Tuckernuck Island, could be accelerated if the present littoral drift patterns south of Nantucket are altered by jetty construction.

106. Since stone or other similar materials would be required for jetty construction the problems concerned with transport overland to the project site would be equivalent to the stone barrier alternate. Old barges were suggested as a possible structural system. These could be floated into position and sunk in place. Navigational hazards arising from accidents while enroute to Madaket could result if, for example, the barges sank in channel areas between New York City and Nantucket Sound. There is also the very real problem of draft clearance to the south beaches of Madaket caused by shoaling within the harbor, and, offshore, south of Smith Point.

HYDRAULIC OFFSHORE DREDGING

107. Closing the breach with rapidly pumped sand from existing offshore shoals without a reinforcing core does not appear to be a technically feasisible alternative. In addition, there may be environmental consequences affecting the south shore beach lines of Madaket and Smith Point of a serious magnitude.

108. One or more 30" diameter suction dredges, drawing 6 feet or more of water for floatation, would be required to build a sand dike across the breach in a 5-knot current. Some 600,000 cubic yards of material would be required. The present shoaling south of the breach and in Madaket Harbor precludes the navigation of these dredges to breach site area. Placement of pipelines offshore south to the shoals would be jeopardized by normal wave and storm activity, assuming proper location of the dredges.

109. A sand barrier, without a hard core would probably erode if continuously overtopped by storm generated waves from the south, and may result, in time, in another breach. Additional sand would verylikely have to be pumped on to the dike from time to time to maintain its integrity, particularly after heavy storms. This approach is similar to the proposed alternative in that it maintains the natural Madaket Harbor setting.

110. Dredging the off-shore shoals would leave a void in a critical area. The present shallows dissipate wave energy before impact on the south beaches, thereby affording some protection. The breach closure structure would benefit greatly if these shoals remained in place.

111. This method would further provide an elevation differential or low bottom area with reference to shoals and tidal flats to the east and west of the dredged section. The normal littoral drift would meet less resistance as it approached the dredged area, and, therefore, increase sand transport volume and speed. The action could have a material effect on south shore beach lines and the rate of recession effecting not only Nantucket mainland but also Smith Point.

112. The lack of harbor shoal dredging would result in similar conditions described under the stone barrier alternative. The environmental and economic benefits of an increased shellfish crop would be lost.

COMPOSITE BARRIER CORES

113. The proposed alternative provides for a sheet steel pile reinforcing core located along the longitudinal centerline of the barrier. Design alternatives utilizing materials other than steel were considered.

114. Many pier, wharf and dike structures in New England waters are of wood construction. The cooler waters inhibit borer infestation and, therefore, reasonably long underwater life may be expected up to 25 years or longer. However, strength limitations indicate some form of cellular design for survival in an application such as the proposed closure. Also, resistance to abrasion caused by sand movement is less than coated steel. Since a more complicated structure would be required, compared to a simple steel bulkhead, costs of installation would tend to offset economies of material inherent with wood. Composite structural systems, cellular in design with stone fillers are feasible. However, again the filler material would necessarily require transport in quantity to the site over local roadways until sufficient dredging in the harbor would allow barge navigation to the breachway. Since sheet steel has a low bulk factor, compared to stone, this material does not develop as serious a transport problem.

115. While plastic or latex cellular materials have high chemical resistance to the Madaket aquatic environment, their limited physical strength exposes them to damage by tearing during placement, and deterioration from erosion if exposed on the top surface of the proposed barrier. The steel or wood system protruding from the top of the barrier would further harden dike resistance to overtopping by waves.

116. The environmental consequences of composite barrier cores are similar to those for sheet steel. The closure location and harbor dredging elements of the project would result in littoral drift effects and shellfish crop improvement, near and long term, as outlined under the proposed project.

NO ACTION

117. This alternative has some importance to a few conservationists and to some local inhabitants, particularly surviving property owners on Esther Island who wish to maintain the insular character of Smith Point. The sociologists report outlines some of the comments received recently (see Appendix 4), regarding the no action alternative.

118. The near term primary adverse impacts would be eliminated. The area would not be disturbed by construction. The harbor water would not be agitated by dredging, and the local roadways would not be subjected to project related traffic.

119. Long term adverse impacts would be mitigated. Recreational development would be retarded, slowing the increase in boat use of the harbor and reducing the pressure on the area for increased beach parking and utility services. Dwelling density would remain stable for a time and Madaket would retain its "summer place" characteristics.

120. On the other hand, the area would continue to be exposed to storm effects from the south. Shoaling in the harbor would continue to expand so that in time, it may not be unreasonable to assume that the entire water area would become a sand tidal flat with some channeling near Eel Point and the present breachway.

121. Shellfishing would be so reduced so that no commercial value would result. The already precarious industry would have little or no economic benefit to the island inhabitants.

122. As navigation continues to be restricted by the harbor shoaling, Hither Creek boatyard and mooring area will be usable by only very small outboard powered boats. It is possible that navigation of any kind in the harbor will ultimately be impractical if the present rate of shoaling from the breachway continues.

Relationship Between Local Short Term Uses and Long Term Productivity

133. Present excellent air quality will not change materially as a consequence of the proposed project. Some increase in internal combustion engine emissions are anticipated from power boat and vehicular traffic. However, present and future controls will reduce the pollution factor from these sources. Furthermore, the dilution afforded by the prevailing winds will continue to be a significant cleansing factor.

134. The loss of natural growth, due to project construction, will be relatively small, and have little measurable effect on the area's productive capability. In fact, the final project landscaping will provide additional beach grass not only on the proposed barrier, but also on immediately adjacent beach areas, increasing the present standing crop. Since the project will not generate a dramatic increase in human population, fauna and other non-human creature productivity in the area should not be significantly affected in the long-term.

135. In summary, all evidence points to the project having no long-term risks to health or safety. The serious continuing decline of Madaket Harbor as a Nantucket water resource provides justification for proceeding with the project now rather than reserving a long-term option for other alternatives.

Irreversible Commitments of Resources

136. The project would involve several irreversible or irretrievable commitments of resources. They are typical for projects of this type which involve remedial construction activity in the public domain.

137. Certain parcels of land will be taken in the Broad Creek area to provide a suitable construction site for the barrier and access for subsequent maintenance. This is an irreversible resource commitment.

138. Human resources for construction and required future maintenance are irreversible and irretrievable. Labor will be expended during the construction period and during subsequent maintenance operations. Coupled with this factor is the irretrievable consumption of fuel by power trucks, cranes, bulldozers and dredges. This equipment will be exposed to loss caused by possible storm activity.

139. While there will be a temporary loss of fishery resources during the project construction period, this effect will be reversible through natural and man-effected recruitment.

135. Fortunately, the major material item for barrier construction is the readily available sand which was transported into the harbor by storm and tide mainly from the pre 1961 Broad Creek barrier beach. This material will be redeposited, via dredging, to its approximate prior location.

MADAKET HARBOR

NANTUCKET, MASSACHUSETTS

FEASIBILITY REPORT

WATER RESOURCES IMPROVEMENT STUDY

MARINE BIOLOGY REPORT

APPENDIX 3

MARINE BIOLOGY REPORT

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Introduction

This report describes investigations undertaken by Marine Research, Inc., during 1974, relative to the existing and potential shellfisheries of Madaket Harbor, Nantucket. The study has focussed upon the influence of shifting sands, resulting from the storm-induced breach in the barrier beach that occurred at Broad Creek in 1961, upon the shellfish productivity of this area, and an evaluation of the shellfishery potential in the area in the event these unstable bottom conditions were controlled.

Investigations were initiated by a preliminary visit to Nantucket, during which Madaket Harbor and the conditions resulting from the breach were viewed from a chartered plane and by boat. The investigation involved meetings with several Nantucket residents and officials to obtain opinions about the existing conditions from local individuals who have seen the changes resulting from the breach and who may be in positions to describe or quantify changes in shellfish populations subsequent to the opening of the breachway. Included in the meetings were Allen Holdgate, shellfish officer; Charles Sayles, a commercial quahogger; Henry Kellenbach, and Walter Barrett. In addition, the town shellfish records beginning with 1955 which describe annual shellfish activities were reviewed; no other reports covering shellfish harvests or shipments were obtainable.

The following statements summarize the observations and conclusions resulting from this initial survey:

1. The only records concerning shellfish activity on Nantucket were the Shellfish Warden's Reports prepared for publication in the

Annual Town Report. Each report beginning with 1955 was reviewed and found to be inadequate for purposes of quantifying the effect of the breachway upon the shellfish populations. Only fragmentary harvest records appeared in these reports and these were insufficient to quantify annual yields of shellfish.

2. Available aerial photographs depicting the gross physical changes resulting from the breach were taken at oblique angles and, consequently, were unsuitable for accurately determining the magnitude of the area adversely influenced by the breach.

3. Shellfish - primarily bay scallops (Argopecten irradians) and hard clams (Mercenaria mercenaria) - continue to be harvested from the area by commercial fishermen. However, according to the shellfish officer, the yield from the area is continually decreasing as the productive bottom decreases in size due to the intrusion and movement of sand.

4. The shellfish populations are reportedly very patchy within the Harbor. At the time of this initial survey, the local clam fishermen were confining their efforts to only a small area of the Harbor near the entrance to the embayment on the southeast shoreline of Madaket. It was indicated that the populations outside this area were too sparse to warrant fishing.

Because of these conditions and circumstances, the following procedures were decided upon:

1. Vertical photographs of Madaket Harbor would be obtained, so that the total area influenced by the breach and characterized by shifting sands could be determined.

2. Bottom samples would be obtained by dredge, rake, tong, and diver at locations characterized by different bottom conditions and water depths. The sampling would be carried out along transects which would be established between easily-seen objects or else would be referenced to land points so that the sampling locations and data can be related to the photographs. The samples would be essentially qualitative in nature but would establish the presence and speciation of shellfish in relation to the nature of the bottom and proximity to the area influenced by the breach.

3. On the basis of the above, the percentage of Madaket Harbor area that constitutes shifted sand and that will probably be shown to be barren and no longer suitable for shellfish, would be calculated.

4. Finally, an estimate would be derived for the potential yield of shellfish from Madaket Harbor if the breach were closed and portions of the Harbor dredged. Recommendations as to how a program in aquaculture might be initiated in the area subsequent to stabilization of the bottom and the benefits which would result from such a program, would also be submitted.

Procedures and Results

Vertical aerial photographs of Madaket Harbor were obtained on 14 May, approximately two hours prior to low slack tide. These photographs were taken by Kelsey Airviews of Chatham, Massachusetts, and are presented as Figures 1a and 1b.

Bottom sampling by dredge, rake, and tong was carried out on May 15th with assistance of Mr. Oscar Bunting, a local fisherman who provided boat and sampling gear. A dead tree, imbedded in the sand in the central area of the Harbor, was used as a reference point for establishing sampling transects and is shown circled in Figure 1a. The May 15th sampling locations are identified in Figure 2 as locations 1-25. Epibenthic samples were obtained at most locations by towing a standard scallop dredge for two to three minutes. Samples of the infauna were collected at each location by tongs or mud hoe.

On August 13th and 14th, bottom sampling and visual inspection of the bottom were carried out by scuba diver in areas of the Harbor not covered on May 15th, and including the area between Eel Point and the western end of Esther Island. These locations are identified by numbers 26-55 in Figure 2. The sampling procedure involved the trowelling of all of the bottom material within a one-quarter square meter quadrat to a depth of approximately ten centimeters into a basket lined with 3 mm mesh. The basket was flushed of sand and mud, and the retained organisms examined

at the surface. Visual inspection was carried out between adjacent sampling locations by swimming along the bottom as the boat moved. Any scallops observed at these times are indicated as "observed" at the next station location.

Since all of the sampling was done from a boat which was subject to being set by wind and tide, it was difficult to maintain exact ranges and bearings from reference points. However, the locations, as determined by magnetic bearings to known shore points, are considered to be sufficiently accurate so that the shellfish density data are reasonably related to the indicated locations.

The results of the sampling efforts are presented in Table I and in Figure 3. As indicated in the legend for Figure 3, the symbols indicate where live shellfish were located. The results of this survey tend to confirm that the light-colored sand areas of the Harbor, clearly evident in Figures 1a and 1b, are for the most part barren of shellfish, and that only the darker areas, characterized by the presence of eelgrass and typical of the harbor prior to the breaching, support shellfish populations. (Eelgrass is an indication of bottom stability; its presence is not required for shellfish.)

For purposes of defining the Madaket Harbor area, an arbitrary line was drawn from the tip of Eel Point to a point on Esther Island (Figure 2). Using this line as the western boundary of Madaket Harbor, it was possible

to determine the proportions of the Harbor area that presently appear to be barren of shellfish and those that are productive, by planimetering the entire harbor and then the light-colored sand areas. The results are indicated below:

Area	Total Acres	% of Total
Harbor	746	100
Unstable Sand Bottom	395	54
Productive Bottom	351	46

It is estimated, then, that more than half the area of Madaket Harbor is now unsuitable for shellfish due to the sandy and unstable bottom conditions. Shifting bottom rarely supports commercial quantities of shellfish which are relatively sedentary and subject to siltation, subsequent interference with their water filtering system, and possible suffocation.

In Figure 4, the proposed dredging area is indicated in relation to the existing sand and shoal bottom. (The stippled zone indicates what appeared in general to be stable and biologically productive bottom characterized by the presence of eelgrass.) If this area were dredged to a mean low water depth of four feet, the area of Madaket Harbor which would be suitable for sustaining the growth of shellfish would be roughly doubled.

Discussion

As indicated earlier, records of the annual shellfish harvest from Madaket, prior to and after the occurrence of the breach, are generally inadequate to permit valid comparisons between the shellfish

harvests prior to, and subsequent to, 1961. (See copies of Town Reports, appended.) Nevertheless, on the basis of conversations with the shellfish officer and local fishermen, it is estimated that Madaket Harbor has in the past yielded in excess of $50,000 worth of shellfish in one year and has represented a resource of considerable significance to the economy of Nantucket. However, due to the continuing intrusion of sand through the breach, the erosion of Esther Island, and the continuing instability of the bottom within the Harbor, the capability of Madaket to sustain a shellfishery is decreasing and, ultimately, this resource may be lost.

It has been proposed to close the breach artificially and to dredge somewhat in excess of 300 acres of the shoal area in the Harbor to a mean low water depth of four feet. As indicated earlier, and assuming no future breach of the barrier beach, this should result in an approximate doubling of the productive shellfish area in Madaket.

It would be fallacious to assume that a doubling in the magnitude of productive grounds would ensure a commensurate doubling of the annual shellfish yields. In most areas of New England, shellfish population densities typically vary widely from year to year, reflecting significant variations in annual reproduction. As an example, for the Niantic River in Connecticut, the annual bay scallop harvest has varied from 3,000 to 45,000 bushels during a twenty-year period (Marshall, 1960). Volumes of food available to a population are finite and usually linked with water circulation; while closing the breach would assuredly tend to stabilize the bottom, a reduction in tidal circulation, and hence lesser amounts of planktonic food,

might occur. Finally, improvement of the bottom for shellfish might also permit or encourage an influx of shellfish predators, such as starfish and predatory gastropods.

However, even conceding these possibilities, the fact remains that the proposed closing of the breach and dredging of the Harbor should be distinctly beneficial, as the following theoretical calculations will show:

According to Mr. J. Richards Nelson, President of Long Island Oyster Farms (personal communication), favorable growing grounds planted with immature oysters may yield in excess of 500 bushels of marketable oysters per acre after one year. Similar yields have been obtained in the past by the Cotuit Oyster Company, according to Mr. Richard Nelson, President (personal communication). This represents a "carrying capacity" of approximately 3500 pounds of meat per acre, which is close to the maximum figure reported by Ryther (1969) for bottom culture. Substituting bay scallops for oysters, and recognizing that the edible portion of the scallop, or "eye," represents less than one-third the total meat weight, such a capacity would be roughly equivalent to 1200 pounds, or 120 gallons, of scallop meat. However, because oysters planted as small seed on the bottom usually require four years to attain marketable size, and bay scallops two years, four "generations" of oysters or two "generations" of scallops would be simultaneously competing for food and space on the hypothetical acre alluded to. Hence the theoretical annual oyster and scallop yields should in fact be 125 bushels and 60 gallons per acre, respectively.

It is erroneous to assume that, if one acre can produce 125 bushels of oysters or 60 gallons of scallop eyes per year, 300 acres will yield 300 times these volumes. It is uncertain as to how appropriate extrapolations may be made for any given area having finite boundaries and finite amounts of food. However, in the case of Madaket Harbor, where--assuming closure of the breach--tidal flow oscillates back and forth over the shellfish beds and where tidal amplitude is rarely in excess of two feet, availability of food could conceivably become a limiting factor for densely populated shellfish.

For example, in order to sustain rapid growth, a maturing oyster requires something in the order of 10^9 food cells, in the form of microscopic phytoplankton, each day (Matthiessen and Toner, 1966). One liter of sea water in the area of Nantucket typically might contain 10^7 plankton cells during the summer months. Therefore, for favorable growth, an individual oyster might require 100 liters of water each day. If the area under discussion is 300 acres, and if the mean tidal amplitude is two feet, the total volume of water made available on each tide, or twice each day, is roughly 2.6×10^7 cubic feet, or nearly 10^9 liters. In short, and as a first approximation, the 300 acres under question might be expected to satisfy the nutritional requirements of 2×10^7, or 20 million, oysters. Should one-quarter of these mature to market size each year, the potential yield might approximate 20 thousand bushels. This is roughly half the volume predicted if the 125 bushel/acre figure was extrapolated to 300 acres under culture.

This estimate is further complicated by various factors. As a positive factor, additional nutritional material for the mollusks might be derived from organic particles, or detritus, derived from the eelgrass beds, as well as from continued growth of plankton in the same water mass. On the negative side, the approximate billion liters, as the estimated tidal prism volume, is not necessarily replenished with planktonic food cells during each tidal exchange. Furthermore, the food requirements of oysters vary as the oyster increases in size, while these calculations have considered all of the oysters as requiring roughly the same amounts of food.

Substituting bay scallops for oysters, and recognizing the two-year, as opposed to four-year, growth period of the former species, an annual harvest of nearly 10,000 gallons of scallop meats might be projected as a first approximation, assuming of course that local natural reproduction was favorable and that predation and losses from other causes were negligible. Marshall (1960) reports an average annual yield of 300 pounds, or about 30 gallons, per acre for the Niantic River, a figure, when extrapolated, that is similar to the projection here. On the basis of the limited data available regarding the food requirements of hard clams, it is estimated that an area capable of supporting 20,000 bushels of oysters could probably support an equivalent volume of hard clams. (During the past year, more than 5,000 bushels of hard clams have been harvested from an area of less than seven acres in Somerset, Massachusetts.) In this case, the assumed mean population density would approximate five mature clams per square foot of area, a density that is high but in fact is frequently exceeded in areas of smaller size, as in Somerset and in parts of Pleasant Bay, Massachusetts.

these yields, although theoretically possible, are seldom obtained, due primarily to inadequate management and to natural factors beyond man's control. Yield projections assume a constant and reliable source of supply of seed stock, regardless of the species in question, and this phenomenon rarely occurs under natural conditions. Even when natural reproduction is favorable, other factors such as predation or adverse weather tend to reduce the yields. The objective of developing shellfisheries in Madaket Harbor is to obtain, consistently, an annual harvest value which constitutes a major element in the projected benefit cost ratio pertinent to the decision to close the breachway. In our judgment, the probable return from an unmanaged fishery which relies exclusively on local natural reproduction and recruitment, favorable natural circumstances that minimize mortalities, and which neglects the necessity of shellfish bed maintenance, would fail this objective. In our opinion, there is even a serious question as to whether or not an intensively managed shellfishery would in fact yield the necessary return on a sustained annual basis, due to the uncertainties inherent in shellfish culture, even though the theoretical yields from an area such as Madaket Harbor are considerable. However, a culture program offers the only means for a sustained level of production and would necessarily require the implementation of techniques involving the planting and protection of seed and controlled harvesting.

Logical species for consideration in such a program would be hard clams, scallops, and oysters. At this writing, sources of seed stock of hard clams

or scallops in quantities sufficient to sustain practical levels of production, and of a size sufficient to be planted safely in natural areas, are not known.

Since seed oysters are available from various sources in New England, it seems worthwhile to discuss the economics of an oyster culture program as they might apply to Madaket. The purpose of the program would be to determine, on a pilot scale, the practicability and economic feasibility of culture before making major decisions concerning Madaket Harbor and the economic potential of its shellfishery. Such a program would contain the following elements.

1) Selection of an area in Madaket Harbor for management

It is recommended that an area roughly 20 acres in size, with a relatively uniform depth of about 4 feet at mean low water (the depth of the proposed dredge area) and sufficiently remote from possible influence from the breach, be selected for cultivation. Possible locations might be immediately north of Esther Island and to the west of the breach, or to the north and east of the Hither Creek entrance.

2) Removal of grass and predators

Grass and predators on the beds should be removed, by conventional or escalator dredge. It is estimated that a period of four to eight weeks would be required for this purpose, depending upon the thickness of the grass and the gear employed.

3) Acquisition and planting of seed stock

If sources of supply of seed hard clams, bay scallops, or other potentially favorable species can be found, these species certainly should be tested on a trial basis. However, as discussed above, sources that provide seed of a size manageable for planting directly on the bottom, i.e., larger than 1/8-inch in shell length or height, are unknown to us. Therefore, this proposed project deals with oysters which are available in quantity and of a size sufficient to be planted on the bottom without the likelihood of severe loss.

The oysters, which should have a minimum shell height of one inch (two-year-old oysters), would be planted at different densities on the bed, in order to establish whether, under prevailing hydrographic conditions, growth rate and quality may be limited at specific population densities. For example, the 20-acre area could be divided into four 5-acre plots, in which oysters would be planted at densities to yield, ultimately, 200, 400, 600 and 800 bushels, or a total of 2000 bushels. Assuming the possibility of a 20% loss between planting and harvest, a total of 750,000 oysters would be planted over the 20 acres, with maximum densities approximating 1-2 oysters per square foot of bottom.

4) Monitoring of beds

It is recommended that the beds be monitored on a regular basis, to determine rate of re-establishment of grass, intrusion and activity of

predators, growth and survival of the oysters, etc. This is best done using scuba gear; during the warmer periods of the year when shellfish predators are generally most active, surveys of the beds should be undertaken weekly. In addition, the possibility exists that local spawning may occur as a result of the planting. Therefore, during the summer months, the waters of the Harbor should be sampled routinely for the occurrence of larvae, and shell cultch should be spread on the grounds if larvae are detected.

5) Evaluation of program

With the planting of two-year-old oysters, it is expected that most of these will be marketable within an additional two-year period. The harvest of these oysters should be carefully recorded to insure that a realistic and accurate evaluation of the program--specifically the volume and market value of production--is made. On the basis of this, it should then be possible to define the results and consider the alternatives:

a) The harvest value clearly demonstrates the considerable economic potential of Madaket Harbor as a shellfish-producing area if management techniques are employed. In this case, the limiting factors as far as Madaket Harbor is concerned would be availability of suitable grounds for culture and the availability of seed in the required quantities. Under such conditions, the proposed breachway closing and dredging would appear distinctly worthwhile.

b) The return is sufficiently encouraging to warrant continuation of the culture program. However, the anticipated benefit cost ratio, at least for the immediate future, does not satisfy the criteria required in order to justify the dredging project.

c) The harvest value is not adequate compared with costs, and the outlook for an improved benefit cost ratio--as, for example, through reduction in cost of seed as a result of local reproduction, or increase in market price--is unfavorable. In this case, termination of the project should be considered, and the chances of a satisfactory pay-back on the breachway closing project would seem sufficiently slim to warrant its abandonment.

The total cost to first harvest is estimated to be $41,000, and the harvest value is predicted to be an equivalent sum. However, the significant benefit to come from this program will be the conclusions reached relative to the potential of breachway closing and shellfishery development.

Upon demonstration on a pilot scale that a culture program in Madaket Harbor would show a significant positive benefit cost ratio, consideration should then be given to initiating a culture program, subsequent to closing of the breach, involving the full 650 acres of bottom in Madaket Harbor. Based on the availability of sufficient oyster spat at a unit cost of approximately 0.15 to 0.2 cents, plus transportation and manpower costs, the estimated annual cost to sustain such an

operation would approximate $50,000. In the fourth year following the initial planting of spat, the harvest value, based on today's prices, could be as high as $300,000 - $400,000, and the investment to that time would be $150,000.

Concurrent with the development of the shellfishery, additional aspects meriting consideration would include the development of an on-island facility for processing the product (eliminating the need to ship whole product including shell) and the development of a reliable source of seed stock utilizing the natural areas and resources of the island.

Summary

1. Field data gathered during this study are sufficient to show that roughly one-half of the Madaket Harbor area is unsuitable for shellfish due to the instability of the bottom. According to local sources, the productive areas of the Harbor are diminishing, albeit at an undetermined rate, due to the continual shifting of sand.

2. Assuming closure of the breach and dredging of the Harbor, the theoretical yield of shellfish from the harbor is projected to be:

    a) 20,000 bushels per year for oysters and hard clams, and

    b) 10,000 gallons per year for scallops.

3. An unmanaged fishery, relying exclusively on natural conditions would result in widely varying and unpredictable annual yields, and would most likely fail to meet the theoretical yield projections.

4. Yields from a managed fishery cannot be guaranteed, but a culture program offers the only means of possibly achieving a sustained, high level of production.

5. A two-year culture program on a pilot scale is recommended as a means of evaluating the potential of production in Madaket Harbor, as well as the problems involved. The results of this program should provide a basis for deciding upon the proposed breachway closure, dredging, and large-scale culture program.

ADDENDUM

Following completion on September 13, 1974, of the Madaket Harbor Study, information not previously obtainable was received from the Broad Creek Committee which showed estimates of the value of the Madaket shellfish harvests from 1953 through 1973. Data pertaining to scallops and quahogs have been excerpted and are shown in the accompanying table.

According to the Committee Secretary, H. L. Kehlenbach, these data apply to the harvest of shellfish in the Madaket area which the committee defines as including the waters from Madaket Harbor westward to the waters adjacent to Tuckernuck Island--an area estimated to be some 2 to 2½ times the area of Madaket Harbor as defined in the report.

Based on these data, the $50,000 annual yield estimate shown in the recently submitted report is considered to be reasonable and acceptable as a figure to be used for comparison purposes with future yield projections of the area.

Shellfish Harvest Value

Madaket Area

Year	Gal. of Scallops	Bu. of Quahogs	Value
1953	22,500	2000	$160,000
1954	42,700	2000	230,000
1955	6,000	2000	56,000
1956	3,000	2000	36,000
1957	6,000	2000	46,000
1958	20,700	2000	120,050
1959	3,100	1500	36,050
1960	9,800	1500	55,000
1961	14,200	1500	134,300
1962	10,500	1500	100,000
1963	9,600	1500	131,300
1964	15,600	1500	100,000
1965	14,200	1000	133,200
1966	8,300	1000	180,000
1967	7,500	1000	153,000
1968	16,600	1000	83,000
1969	8,100	1000	109,000
1970	6,000	1000	89,000
1971	4,100	1000	81,800
1972	7,000	1000	162,000
1973	3,500	1000	95,500

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Marshall, Nelson. 1960. Studies of the Niantic River, Connecticut, with special reference to the bay scallop, Argopecten irradians. Limnology and Oceanography, 5 (1).

Matthiessen, G. C. and R. C. Toner. 1966. Possible methods of improving the shellfish industry of Martha's Vineyard, Duke's County, Massachusetts. A Publication by the Marine Research Foundation, Inc., Edgartown, Massachusetts.

Ryther, John H. 1969. The potential of the estuary of shellfish production. Proceedings of the National Shellfisheries Association, 59.

Table I. Madaket Harbor Shellfish Survey

Sampling Date: May 15, 1974

Location No.	Bottom/Vegetation	Live Shellfish
1	Mud Sand Moderate grass	1-Q* 3-C 8-S
2	White sand over grey sand and gravel	
3	White sand	
4	Two inches of sand over shell and grey mud	
5	White sand Broken shell	
6	Grey and brown mud Light grass	
7	White sand	1-S 1-C
8	White sand Gravel	
9	White sand Broken shell	
10	White sand	
11	Black mud Heavy grass	4-S
12	Black mud Heavy grass	5-S
13	Thin layer of white sand over brown sand	
14	Brown sand Light grass	
15	White sand Broken shell	

Table I. Madaket Harbor Shellfish Survey (continued)

Sampling Date: May 15, 1974 (continued)

Location No.	Bottom/Vegetation	Live Shellfish
16	White sand	
17	White sand	
18	Black mud Heavy grass	20-S
19	Brown sand Mud Heavy grass	1-Q 2-S
20	Brown sand Light grass	
21	Black mud Medium grass	
22	White sand Gravel	
23	White sand	
24	White sand	
25	Black mud Heavy grass	Numerous-S

Sampling Date: August 13-14, 1974

Location No.	Bottom/Vegetation	Live Shellfish
26	Loose sand over fine mud	
27	Fine, loose, rippled sand	
28	Sand-gravel mixture	2-SC
29	Sand-gravel mixture	Few - M
30	Fine rippled sand overlying peat	

Table I. Madaket Harbor Shellfish Survey (continued)

Sampling Date: August 13-14, 1974 (continued)

Location No.	Bottom/Vegetation	Live Shellfish
31	Loose rippled sand	
32	Loose shifting sand	
33	Loose rippled sand	
34	Sand/Eelgrass	
35	Sand, silt/Eelgrass	1-S
36	Sand, silt/Eelgrass	
37	Sand, silt/Eelgrass	4-S
38	Sand/Eelgrass	Numerous-S (observed)
39	Sand, mud/Eelgrass	Numerous-S (observed)
40	Sand/Eelgrass	
41	Loose ripples sand	
42	Loose rippled sand/ Eelgrass	
43	Coarse gravel/Eelgrass	
44	Coarse sand-gravel/Eelgrass	
45	Coarse sand-gravel	
46	Sand, gravel	2-SC
47	Sand, gravel	
48	Sand, silt/Eelgrass	
49	Mud/Eelgrass	
50	Mud/Eelgrass	

Table I. Madaket Harbor Shellfish Survey (continued)

Sampling Date: August 13-14, 1974 (continued)

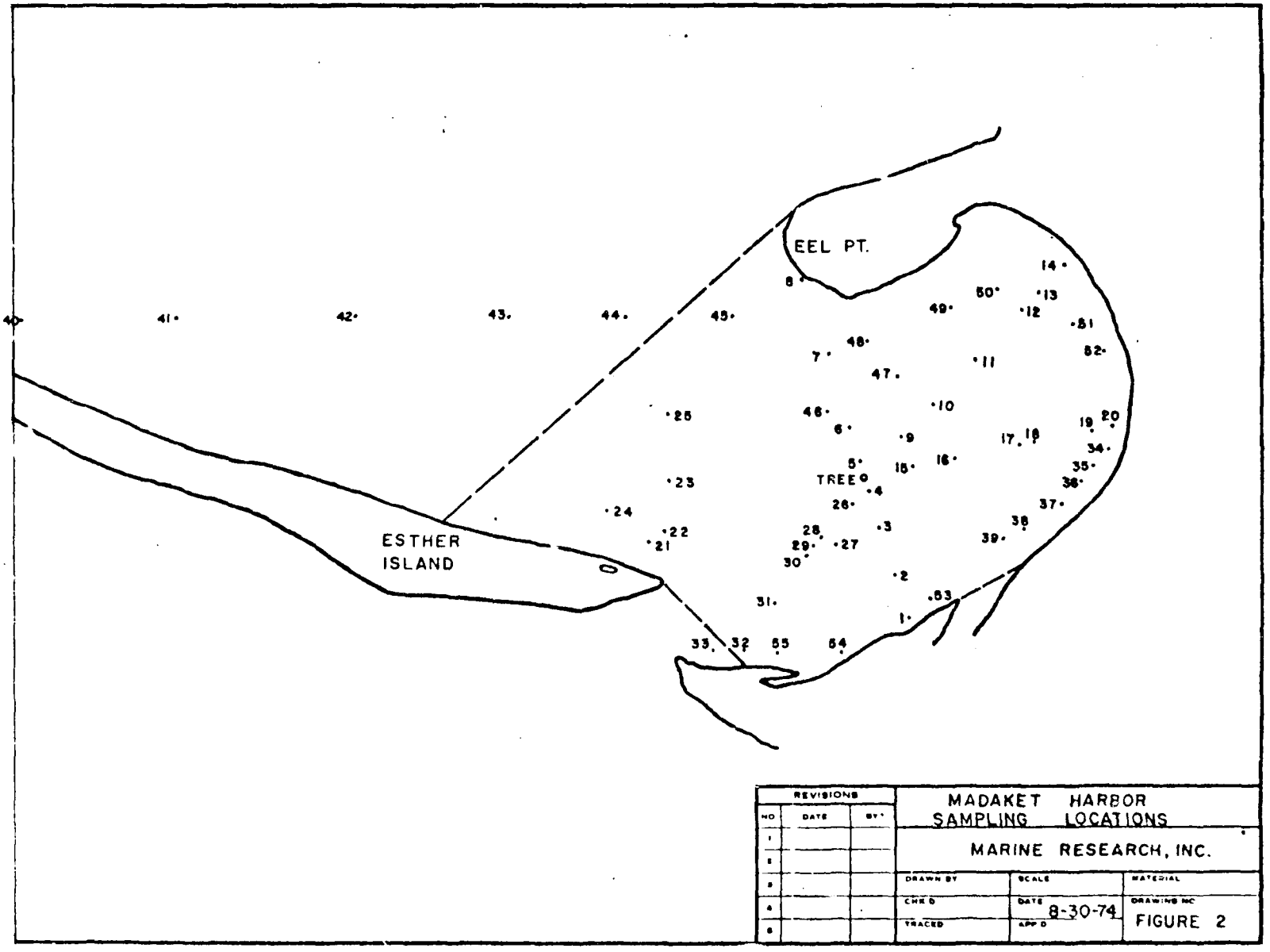
Location No.	Bottom/Vegetation	Live Shellfish
51	Mud, sand/Eelgrass	Numerous-S (observed)
52	Mud, sand/Eelgrass	Numerous-S
53	Mud, sand/Eelgrass	Numerous-Q
54	Sand/Eelgrass	Numerous-S
55	Sand, gravel	

* Q Quahog
S Scallop
C Clam
SC Sea Clam
M Mussel

AERIAL VIEW OF MADAKET HARBOR MAY 1974

PLATE 3-1

PLATE 3-2



REVISIONS		
NO	DATE	BY
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MADAKET HARBOR
SAMPLING LOCATIONS

MARINE RESEARCH, INC.

DRAWN BY	SCALE	MATERIAL
CHK'D	DATE 8-30-74	DRAWING NO. FIGURE 2
TRACED	APP'D	

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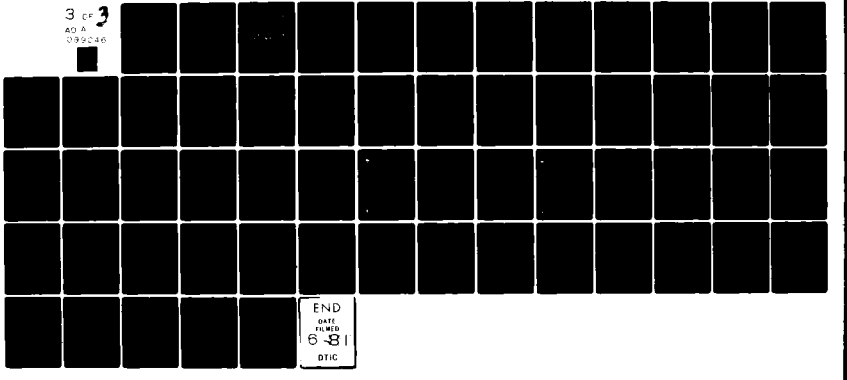
MADAKET HARBOR, NANTUCKET, MASSACHUSETTS. WATER RESOURCES IMPRO--ETC(U)
JUL 77

UNCLASSIFIED NL



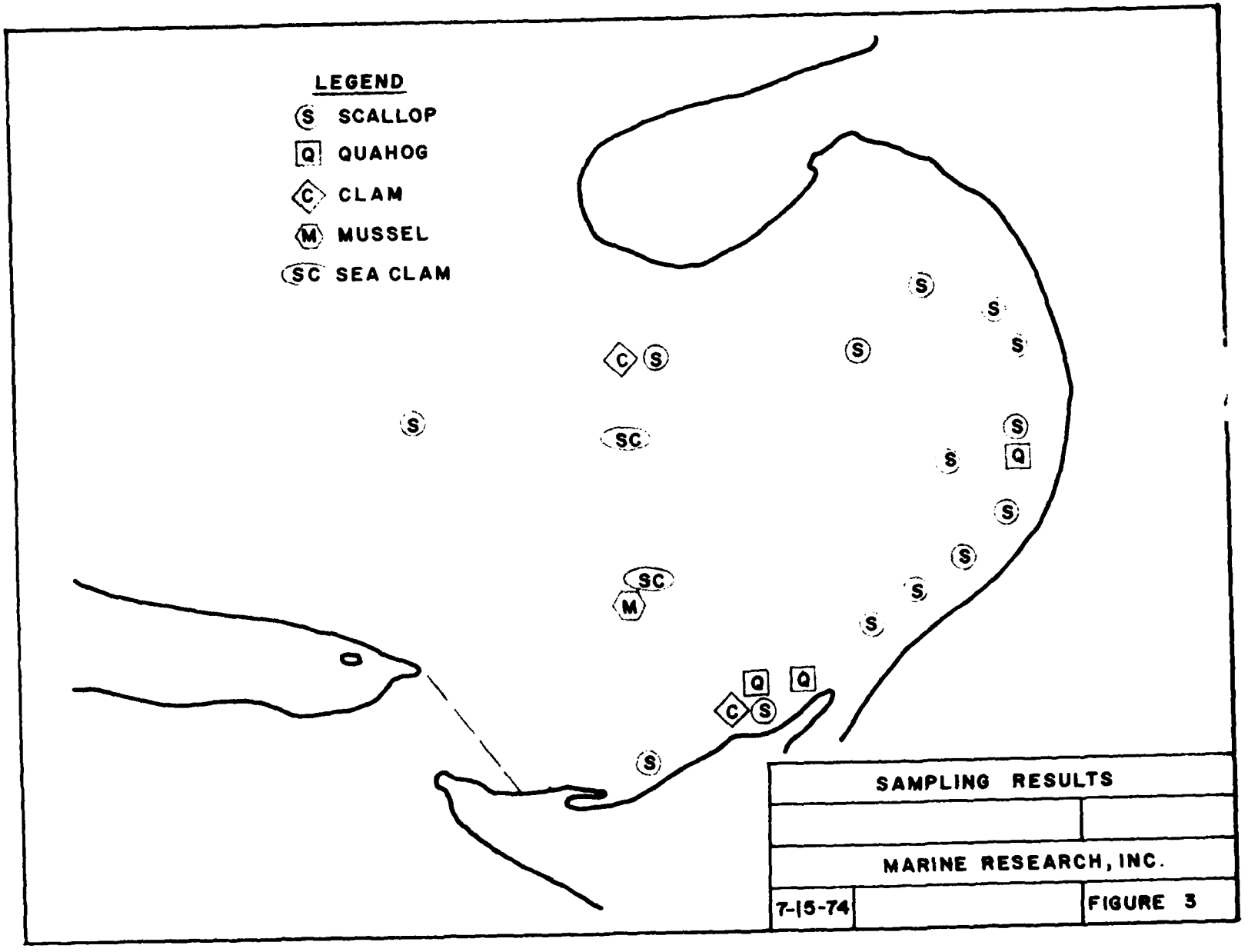

LEGEND
S SCALLOP
Q QUAHOG
C CLAM
M MUSSEL
SC SEA CLAM
SAMPLING RESULTS
MARINE RESEARCH, INC.
7-15-74
FIGURE 3

PLATE 3-3

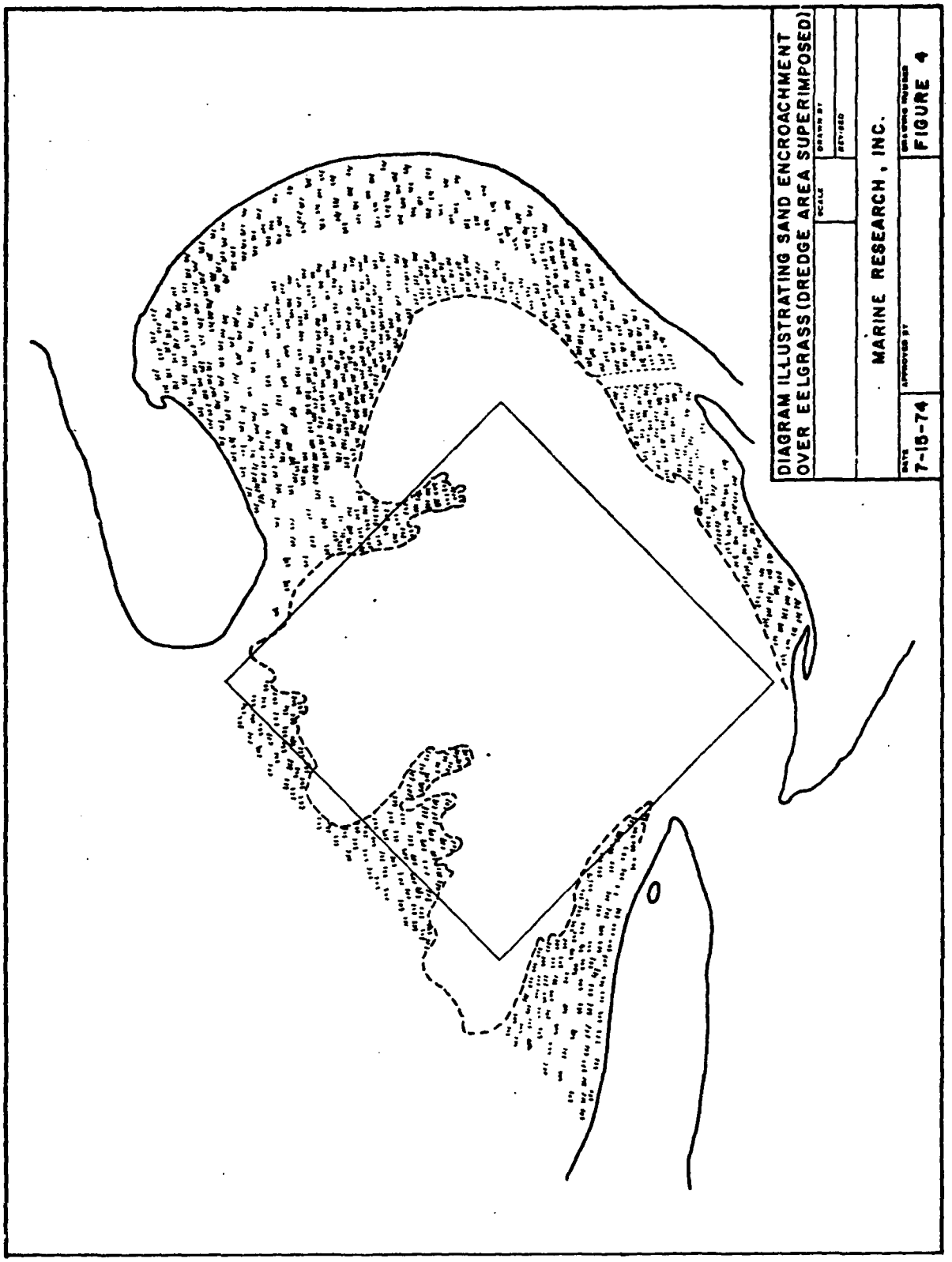


DIAGRAM ILLUSTRATING SAND ENCROACHMENT
OVER EELGRASS (DREDGE AREA SUPERIMPOSED)
SCALE
DRAWN BY
REVISED
MARINE RESEARCH, INC.
DATE
7-15-74
APPROVED BY
DRAWING NUMBER
FIGURE 4

PLATE 3-4

MADAKET HARBOR
NANTUCKET, MASSACHUSETTS
FEASIBILITY REPORT

WATER RESOURCES IMPROVEMENT STUDY

SOCIAL EFFECTS ASSESSMENT

APPENDIX 4

SOCIAL EFFECT ASSESSMENT

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Madaket Harbor Water Resources Improvement Study
Sociologist's Report

I. The Study and Report

A. Purpose and Authority

The purpose of this report is to assess the social effects and segments of the economic effects of the proposed project to close the breach in the barrier beach at Madaket Harbor. This assessment has been accomplished by taking into regard the opinions of a sample of the population of Nantucket Island along with a review of available data. This data collection and review has been accomplished in accordance with a contract with Tibbetts Engineering Corporation.

B. Scope of the Report

This report involves over 100 man hours of work. It includes (a) the collection of background information regarding the social effects of the proposed project at Madaket Harbor, (b) interviews and collection of background information on Nantucket Island from June 4, 1974 through June 7, 1974, and (c) review and assessment of the collected information including the preparation of both verbal and written reports.

This report has been prepared by Harold F. Cooper, Ph.D., Associate Professor of Sociology at Cape Cod Community College, West Barnstable, Massachusetts.

C. Summary of the Report

Overall it appears that the proposed project should be implemented as soon as possible. Although there is some difference of opinion among the persons interviewed as to the priority of, the necessity for, and the feasibility of the proposed project, there is general support for the project if it is not injurious to the surrounding area and can be well done with a minimum of expense to the taxpayers of Nantucket Island. There is some personal opposition to the project on the part of some of the persons connected with the conservation agencies and the University of Massachusetts Field Station. (See interviews #22 and #23 Appendix "B".) However, no organized opposition was uncovered and no attempt on the part of anyone to organize opposition to the proposed project was discovered. In general the project is viewed as positive to the economy of the Island and not injurious to either the people or the social/physical environment of either the Madaket area or the total Island area.

D. Studies and Reports Consulted

Valuable sources of information used have included publications and data from the United States Bureau of the Census, the Massachusetts Division of Employment Security, the Massachusetts Department of Commerce and Development, the Cooperative Extension Service of the University of Massachusetts (Amherst), and other compilations of data regarding Massachusetts.
Of particular interest has been the report of a study done on

Nantucket in the summer of 1966 (Zube, Ervin H., "An Approach to Resource Interpretation," in The Massachusetts Heritage, Vol. V, No. 1, April 27, 1967).

II. Resources and Economy of the Study Area

A. Environmental Setting

No historical or archeological sites appear to be affected by the proposed project.

The area has been a "summering" spot for local inhabitants, with several currently living "in Town" in the winter and in Madaket in the summer. The past few years have seen a rather rapid increase in residential land use in the Madaket area. Construction has included year-round homes, summer cottages, and an extensive year- round and summer condominium development as the most prominent change. This growth has brought with it an increase in both the use of the land and the use of the harbor and ocean area surrounding Madaket. The Madaket area, once looked upon as an isolated locale by the Island inhabitants, can no longer be considered isolated with limited access. There have been and it appears there will be important increase in the recreational use of land and water, including sport fishing. The harbor area is also important as the arena for commercial shell fishing.

B. Human Resources

The 1970 year- round population of Nantucket reported by the 1970 census is stated to be 3,774. Essentially this has remained unchanged

over the past few decades except for a reduction during the years of World War II. Many local inhabitants felt that the 1970 census referred to military personnel and their dependents, and claim the year-round population to be larger than this figure, and estimate it to be anywhere from 4,800 to 5,600. It appears that the summer population must be at least four times that of the"off-season" and it has been estimated in"An Approach to Resources Interpretation" by Ervin H. Zube at over 16,000.

Regarding the number of years of education completed, the year-round residents of the Island compare favorably with other populations in the State. Partially this is due to the in-migration of some portion of the population with high educational characteristics, and the slow but continuous out-migration of a portion of the younger population.

Occupationally much of the population is engaged in some type of work related to tourism and recreation. (Nantucket has been a popular summer resort since the late 19th century.) The types of skills reflected in the population demonstrate this fact. Numerous year-round residents also engage in fishing. Available official data are probably not very reliable in regard to the number of fishermen. Many appear to do this part-time. The fin fish and shell fish obtained are a regular diet supplement as well as a source of income.

The year-round population of Nantucket will probably continue to grow slowly due mainly to migration. Most of the growth will probably involve persons engaged in occupations related to tourism and recreation.

As has happened on Cape Cod and other

similar areas there is a current trend toward extension of the tourist/recreation season, beyond the July to Labor Day time period.

The Madaket area appears to have had a slow year-round growth in population, as well as a rather rapid seasonal growth in population. Both of these trends should continue in the near future.

C. Development and Economy

Major sources of employment on Nantucket - both summer and winter - include wholesale and retail trade, service related industries and the construction industry. It may be concluded that these sources of employment are tied quite directly to the total enterprise of tourism and recreation. Fishing is a source of employment which could be termed indigenous, and finfish and shellfish could be sold elsewhere if tourism and recreation slow. It is for this reason that fishing as an industry should be encouraged in a rational, planned, and controlled manner with much thought for the future. The combination of added food resource, even if small, and an increased source of steady employment for the Nantucket year-round population is positive.

Recent official data on unemployment show that there is a substantial seasonal variance ranging from over 12% in the winter to less than 3% in the summer. After discussions with persons on the Island (including an employee working for the Massachusetts Division of Employment Security) it may be concluded that these unemployment statistics are approximate

at best. There may be more actual unemployment, suggesting once more that added employment sources of a nature congruent with the interests and skills of the year-round population (such as fishing and fishing related occupations) would be welcomed.

Future projections would have to admit to a continued reliance upon tourism and recreation as the basis for the Island's economy with a possible increase in the current trend. Any encouragement for alternatives should be supported if one agrees with the point of view that diversity is a positive factor in a healthy society.

III. Problems and Needs (as reported by those interviewed)

This section of the report will deal basically with the data gathered in the interviews with members of the Nantucket population. (See Appendix A for a brief methodological statement and Appendix B for a further summary of data.)

Approximately 75% of the persons interviewed expressed opinions ranging from support for the proposed project if done well and with minimum expense to Nantucket taxpayers. Approximately 25% expressed some reservation beyond the possible expense of the proposed project. It is possible that this latter group is over represented in the interview sample as it was felt necessary to consult with representative conservation-minded persons who might have opposition to the project.

Those persons in favor of the proposed project by and large felt that the project should be accomplished as soon as possible and that enough discussion had taken place. It was often pointed out that the breach had occurred partly due to man's mistakes (vehicular traffic over the dunes, poor maintenance of the barrier beach, etc.) and therefore man should close the breach. The partial ruination of the shellfish industry was often cited, along with the problems created for the Boat Yard, as well as the danger created for both commercial and recreational boating. Those interviewed who own property in the madaket area were mainly in favor of the proposed project, including one person who claimed ownership of land on Esther Island. However, one person who had previously owned property on Esther Island (and was personally opposed to the project) stated that at least one of the people now owning land on Esther Island would be opposed to the closing of the breach (apparently due to a desire for personal privacy during the summer season).

No one holding opposition to the proposed project felt they would attempt to organize community opposition to the project or that anyone else would do so. Most of the opposition was not due to any injurious effect that the proposed project might have to the surrounding area (although one person thought Esther Island made an excellent "untouched" botanical area), but was due to feelings that the breach was a natural occurrence

and therefore should be left alone; the feeling that it would close by itself; the feeling that the closure was not a priority item and would be too expensive; the feeling that the breach would not remain closed or another breach might occur nearby. One person expressed the feeling that "the fishermen" might not support the proposed project if it was going to cost the taxpayers a good deal of money. The possibility was voiced that any large appropriation by the Town would be voted down in the Town Meeting.

It was generally agreed by all that the closing of the breach would enhance or at least not detract from land and housing values in the Madaket area, particularly in those areas close to the beach. It was not generally assumed that community growth would be affected by the project. Leisure opportunities and boating safety were generally agreed to be positively influenced by the project. There was some necessary interruption of the enjoyment of the area visualized as occurring during construction of the project, particularly if that took place during the summer season. There was some difference of opinion as to how to get the materials to the construction site, however, any associated problems were generally acknowledged to be solvable. One person associated with one of the conservation groups did mention, however, that land owned by the organization should not be affected or the organization would take steps to halt such trespass (the individual was personally opposed to the project for the reasons stated above).

Public facilities and services, and business activity and employment were in general considered to be influenced positively or at least not adversely by the proposed project (one person stated that a second harbor was necessary to the economic and social health of the community so that there would not be a monopoly). There was the minority feeling that the resulting services and boost to the economy would not be enough to justify the project.

In summary it should be emphasized that the majority view was that the project should be begun as soon as possible, and the minority view held that the project would not be injurious to the surrounding area but probably "wouldn't get funded anyway, so why worry." There was an underlying feel. of frustration on the part of many respondents that "the government" would only talk about the project, **and** wouldn't act. Evaluation of the encountered opposition reveals that such opposition is unbounded, not unified, and in general has no intent in fighting the project.

IV. Comments on the Proposed Plan

The Island of Nantucket and specifically the Madaket area will certainly continue to exist without the proposed project. The main industry, tourism and recreation, will continue to support directly or indirectly the economy of the area. However, without the proposed project it appears that there will be fewer alternatives for employment; that a traditional industry (fishing) will be negatively affected; that only one harbor, Nantucket Harbor, and the resultant business surrounding it (including

the Boat Yard) will be able to grow and operate effectively; and that boating will be less safe in the Madaket area (note the changes occurring between Tuckernuck Island and Smith's Point). It does not appear that the area will be negatively affected in any significant fashion by the closing of the breach. It is true that Esther Island will once again become accessible and will not be a separate island. Yet if the operation of land vehicles was effectively controlled or eliminated in this area, even the present seasonal residents of Esther Island should largely be unaffected in regard to their privacy.

The construction of the closure should be done in such a manner that the operation and maintenance costs would be minimized. The year-round population of the Island is not affluent and any ongoing expense for them should be as small as possible. Finally, the population of the Island and particularly organized groups should be kept thoroughly appraised of the progress of the project proposal and the resulting project if it is constructed. This could be done effectively through the local news media and public meetings. It should serve to reduce the public's feeling of "helplessness and frustration."

In summary, it should be emphasized that the project could be an important influence in the life of a significant portion of the Nantucket population. Increased shellfishing, one source of employment during the "off-season" (tourist/

recreation season), could prove an effective means of helping to reduce the effects of poverty* in the population. Secondarily, the project could operate as a morale incentive for many people. The feeling that someone cares about their livelihood could be an important morale booster if the project's positive results for the shellfishermen are emphasized and realized.

V. Recommendations

Assuming the construction of the proposed project it is recommended that:

1) Further research be conducted by those involved into the utilization of a fishing cooperative.

2) Control of the shellfishing industry be more thoroughly researched and possibly instituted. This should include control of fishing and planned maintenance of the fishing areas. This might partially be effected by stronger licensing procedures.

3) Vehicular traffic across or around the closure should be strictly controlled if not totally eliminated.

4) Programs of careful dune growth and proper plantings should be carried out in the area of the project.

5) If possible, land usage on what is presently termed Esther Island should be controlled. New housing probably should not be constructed. Actually this locale would make an excellent additional conservation area.

(*See Appendix C.)

Appendix A

A Methodological Note

Prior to the actual visit to the Island, data regarding both the Island and the proposed project were studied. The author of the report then contacted two persons known to be familiar with the population of the Island. The first, a colleague and longtime summer resident of Nantucket, proved to be of invaluable assistance in orienting the author and appraising him of local situations which otherwise would have been beyond the scope of the report. The second individual, a mature college student who has resided on Nantucket most of her life proved to be of even more assistance. It was decided that she should be employed as a guide and local informant for the report. This facilitated the actual interviewing, allowing the author to begin work almost immediately upon arriving on the Island, and to achieve an efficiency and make local contacts which would otherwise have been impossible without much more time and expense involved.

Given the limitations of this report and the peculiar aspects of the Island community, it was decided to interview persons from key segments of the population and to follow-up "leads" as they came to light. This often led us from one interview to a series of other interviews. The interviews were conducted in an informal manner. No formal interview

structure was attempted, however, similar questions and issues were raised in each interview. Open-ended questions and probes were utilized.

Over thirty interviews were conducted. Persons consulted represented the business community (owners, managers and employees); the media; elected officials; State and Town employees; State, Town and private agencies engaged in conservation related matters; various organized groups; fishermen; the clergy; the schools; and land owners in the Madaket area.

Appendix B

The following information summarizes the content of the major interviews conducted on Nantucket. Other persons were consulted, however, because of lack of time or depth involved the discussions are not summarized.

Names are not included in the summarized information as the researcher would consider this a breach of professional ethics. In any study of this type anonymity should be preserved unless participants in the study are told prior to the interview that their names will be published.

Tuesday, June 4, 1974

1. Clerk in private office. - Not well informed. However, in support of the project as long as it would aid the economy.
2. Business person. Should be done to improve the economy as well as to protect the land area close to the breach.
3. Business person. Personally in favor of the project. (Hoped the researcher would see some persons who "know" the area.)
4. State employee experienced in social welfare work. - If the project would aid the economy, even slightly, it would be good for the poorer people.
5. Town employee. - Thinks the project should be accomplished. Fishermen would be helped. (However, appears not well informed -

fails to recognize certain land changes in the area.)

6. Former State and Town employee with experience on the Island in social welfare work. - If the project would significantly benefit the local shell fish industry it would be a favorable venture. However, skeptical of whether or not the project can actually do this. Wonders if a break will appear somewhere else. Feels it is difficult to predict and control the action of the ocean in such areas. Generally opposed to the project, yet considers positive factors.

Wednesday, June 5, 1974.

7. Business person/Town employee. - The project should be done. Notes the erosion of land at various points on Esther Island. Main opposition will be from sport fishermen because they enjoy the breach as a good place to fish from shore. Need barges to bring in the steel and equipment. The roads might not stand up to the pressure. The Town helped cause the breach and should aid to closing it.

8. Business person/owns land and residence at Madaket. Sees nothing negative by accomplishment of the project. Even the wildlife (hares) on Esther will be aided. The fishing will be aided but particularly the land will be protected and safety in the Harbor will be improved.

9. Long term resident. - The project should be done. It should help all involved. Emphasizes in particular the increased recreational safety which will occur due to the project.

10. Business person/part-time resident of the Madaket area. - Appears particularly interested in having the project accomplished due to possible increased erosion if it is not done.

11. Business and professional person/owns land and residence at Madaket. - Very positive to the project. Emphasizes the economic impact in regard to shellfishing. Feels this is the major factor in the project. Notes that some people worry about a break at Hither Creek. Doubts whether this or other breaks would occur. Appears quite knowledgable about the various factors involved.

12. Long time resident; now mainly in the summer. - Emphasizes the positive aspects which the project will bring, from an increase in shellfishing to the increased safety for local children. (Says all the mothers of Madaket are for the project because the breach is a hazard for children in boats or on shore). Stresses the importance of keeping organizations and influentials informed about the progress of the project.

13. One of the major persons involved with the local news media. - Sees no reason why the project shouldn't be done. All factors seem positive.

14. One of the major persons involved with conservation on the island. - Personnaly opposed to the project, however, sees no possibility of organized opposition. The breach might close by itself. In any case the money involved in the project cannot be justified. The dredging might even harm the existing shellfish beds. Also, the interest of persons owning land on Esther Island should be considered. They do not want the project.

he feels. There is support for the project simply because everything is done by a "you scratch my back I'll scratch yours" principle.

15. State employee. Long term experience in social welfare work on the Island. - Feels the project could economically aid the population.

16. Town employee/land owner on Esther Island (by his own claim). - Need the project for the shellfishermen. No problem getting equipment, steel, etc. over the roads. (He should be knowledgable in this area.) The town aided in causing the breach and now ought to close it.

17. Long time resident; now retired. - Feels the project is a waste of money for it can't be effectively accomplished.

18. Summer resident and Town employee/student/family owns and operates one of the major inns. - Sees no reason strong enough to oppose the project. Conservation should be a major concern.

19. Older, long time resident. - Feels money could be spent better in other ways. Accepts breach as a natural phenomenon.

Thursday, June 6, 1974

20. Business person and part-time shellfisherman. - Rather cynical about the project. It should have been done before this. Of course it will aid the fishermen, but apparently all that is occurring is "talk."

21. Educator/part-time fisherman. - Is positive about the project,

however, feels it can be accomplished in a cheaper fashion just as well. Acknowledges money problems. Feels the closing is necessary for shell fishermen. The break will probably not close by itself. Controls are necessary as the mistakes by the Town and continued vehicular traffic helped cause the break in the first place.

22. Educator/conservationist/sometime fisherman. - Personally opposes the project. Sees no organized opposition. The breach might close by itself. The project could cause even more erosion. However, it is most difficult to predict in these areas. The Town probably would not vote to appropriate any significant amount of money. Claims even some shell fishermen would be opposed if, for instance, taxes would be higher. Town did make some mistakes in the area of dune growth. He feels the Town did not take the proper measures to insure the growth of the dunes. Others stated that the Town moved sand ineffectively in the area, put fences in ineffective places, and allowed the use of vehicles in the area, all of which hastened the occurrence of the breach.

23. Educator/conservationist. - Basically the same testimoney as above (#22), although, each person was interviewed privately. However, this person states no damage will be caused by the closing of the breach.

24. Business person (in several enterprises). - Has some business in enterprises related to the Harbor. Very cynical about the organizations involved in the project. Feels he has the data to show why the project should be done but feels all concerned will continue to talk about it (for their own benefit).

25. Business person. - Work is related to the Harbor area. Major point appears to be "stop talking and start working."

26. Clergyman/conservationist. - Doubts if the project should have high priority. Questions whether or not the Town would appropriate any significant sum of money. Emphasizes one cannot fight the "forces of nature."

Friday, June 7, 1974.

27. Former land owner on Esther Island/conservationist. - Vigorously opposed to the project. Leave Esther Island undisturbed. One can't fight the forces of nature. The beach grass is now much more healthy on Esther Island than elsehwere. Claims the person to whom she sold land opposes the project also.

28. Fishing boat crewman. - Positive to project. Emphasizes safety aspects along with shell fish availability.

29. Business person/owns and operates fishing boat. - Sport fishing will not be particularly affected, however, access to the Harbor for any larger vessels than his will be limited or impossible if shoaling continues. States that shell fishermen really need the project. Has much data regarding the Harbor. Vigorously favors the project.

(Comment on poverty.)

Poverty is in evidence on Nantucket Island. The median income on the Island is lower than the median income for the State in general. Also, on the Island there is a larger percentage of persons listed in the lowest income category than in the State in general. (U.S. Census Reports) The unemployment rates can also be used as an indicator of poverty. (Approximately 12% in the Winter and 3% in the Summer.) These rates appear to show that a fair percentage of the population relies upon part-time employment for its income. Part-time employment generally brings lower wages and fewer fringe benefits.

If the project were to be instituted and the community were to administer an aqua culture program a number of opportunities for employment would be opened for members of the Nantucket population who must now rely upon part-time employment. An aqua culture program would save the existing shellfish industry in the Harbor and should cause growth in the industry. This growth would allow more persons to be engaged in fishing. However, even more persons would be employed in fishing related industry. The aqua culture program itself would need workers. There would be the possibility for the opening of a freezing plant. Processing of the fish could begin to take place on the Island. These operations would need workers. The type of work would fit the skills of many part-time workers on the Island. A growth in the shellfish industry would certainly give greater economic opportunity to those who need it.

If the project were completed but an aqua culture program were not instituted a benefit would still accrue to the working population of the Island. For shellfish productivity would still increase thus employing more persons in fishing, and there would still be the possibility of profitable freezing and processing operations on the Island.

MADAKET HARBOR

NANTUCKET, MASSACHUSETTS

FEASIBILITY REPORT

WATER RESOURCES IMPROVEMENT STUDY

PERTINENT CORRESPONDENCE

APPENDIX 5

PREPARED BY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

PERTINENT CORRESPONDENCE

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UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Post Office and Courthouse Building
BOSTON, MASSACHUSETTS 02109

December 10, 1975

MADAKET HARBOR, NANTUCKET, NANTUCKET COUNTY, MASSACHUSETTS

Supplement Report of the U.S. Fish and Wildlife Service on the Study of Navigation Improvements for Madaket Harbor navigation project by the U. S. Army Corps of Engneers, New England Division.

This report is prepared and submitted under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U. S. C. 661 et seq.). It is our reassessment of project benefits in light of current information and supplements shellfish and finfish values discussed in our Conservation and Development report, dated June 29, 1972.

Project Description

We understand that the proposed plan of improvement provides for the closing of the breach between mainland Nantucket and Smith Point (Esther Island) to prevent littoral drift from transporting sediments into Madaket Harbor. Closure would involve constructing a dike approximately 3,000 feet long and 410 feet wide on the mean low water plane with a crest elevation at 11 feet above mean low water. Barrier fill material (sand) would be obtained by dredging a portion of the harbor to a depth of approximately 4.5 feet mean low water. The area to be dredged was selected so as to restore approximately 395 acres of bottom to shellfish production. The average annual project cost is estimated to be $344,000.

Environmental Setting Without-the-Project

Madaket Harbor, Nantucket's second largest harbor, has an interior area of approximately 746 acres. It is located on the western extremity of Nantucket and is bounded on the north by Eel Point and on the west by Smith's Point. Hither Creek, an estuary in the southeast section of the harbor, provides sheltered mooring and two public landing facilities.

The harbor shoreline has high dunes and related vegetation on the north and southwesterly sides (Eel Point and Esther Island, respectively) with the

remainder characterized by low sandy beaches with some vegetation and minor dune formation.

The southern end of the harbor is characterized by active currents and high wave energy. Its relatively narrow width and low dunes offer little resistance to storm surge. Storm action has breached the lower southern section through to the Atlantic Ocean at a point locally known as Broad Creek Opening.

Extensive marshland and eelgrass beds along the harbor's northern and eastern shores serve as a trophic base for finfish, waterfowl and shellfish. Finfish species present include alewife, bluefish, cunner, sand dab, American eel, flounder, white hake, tomcod, striped bass and tautog.

No significant change in the average annual commercial landings for the major finfish species and lobsters appears to have resulted from the breach. The following catch statistics, taken from our 1972 report, are essentially the same with the exception of the striped bass.

Species	Pounds	Value*
Bluefish	3,000	$ 240.00 @ $0.08/lb
Herring	5,000	$ 150.00 @ $0.03/lb
Striped bass	6,000	$ 2,400.00 @ $0.40/lb
Lobster	6,600	$11,154.00 @ $1.69/lb
TOTAL		$13,944.00

Although some minor and immeasurable reduction in the aforementioned species may have resulted from the breach, no economic "loss" can be determined. Average annual increases in these fishery resources predicted on page 5 of our 1972 report should therefore be omitted.

Madaket Harbor is extensively used by waterfowl and shorebirds during spring and fall migration periods. The variety and abundance of these birds decreases during the summer and winter periods. Eider, old squaw, scoter, scaup, goldeneye, bufflehead, widgeon, canvasback, mergansers, black duck, mallard and Canada goose are the principal waterfowl species which utilize the harbor area. Despite limited hunting pressure for waterfowl, there is substantial opportunity for this activity.

Shellfish species present include oyster, lobster, soft-shell clam, quahog, bay scallop and surf clam. With the breach, an increase in the surf clam

* Based on current Fisheries Statistics No. 6710, "Massachusetts Landings, Annual Summary 1974", July 3, 1975. NOAA-National Marine Fisheries Service. (Average price per pound at New Bedford, Mass.)

population of Madaket Harbor is anticipated due to improved conditions for that species. However, there are no data available at this time to indicate that a surf clam population of commercial importance has, or will, develop in the harbor.

As a result of the breach, approximately one-half of Madaket Harbor's productive (stable) bottom has been covered by shifting sands, thus reducing commercial shellfish benefits. Table 1, page 4, shows that an average annual reduction of 4,649 bushels of scallops and 750 bushels of quahogs, having a combined value of $86,610.00 has apparently resulted from the breach. Furthermore, because of complex geologic and hydrographic processes in the area, future coastal morphology and fishery resources cannot be easily predicted. Assuming that an equilibrium state has been established, no further reduction in the harbor's productive capacity would be anticipated. However, if erosion and sedimentation continue, additional losses of productive shellfish and wildlife areas may occur. Without-the-project, and barring a natural closure, reclamation of those areas removed from production because of the breach, may not be possible.

Because of limited pressure, recreational shellfishing needs on Nantucket can be met without the project by reliance on other areas.

Environmental Impacts With-the-Project

Closure of the breach and dredging of associated shoal areas to -4.5 feet mean low water would provide the opportunity for re-colonization of approximately 395 acres by scallops and quahogs. Also, barring any future disruption of the harbor area, the continued use of existing fishing grounds inside the harbor would be assured.

Similar restoration in waterfowl habitat can be realized through stabilization of the harbor bottom. Closure of the breach would also assure continued use of this habitat.

The Tibbetts Engineering Corporation Feasibility Report (Appendix-1, No. F-1) attributes $422,820 (average annual gross value) to shellfishery benefits with-the-project. These are based, in part, on hypothetical yields made possible by intensive mariculture. We believe, however, that harvest predictions, based on natural production (with closure of the breach), provide a more accurate reflection of with-the-project values and are therefore provided in this report.

Two sets of values representing (1) the expected average annual benefit attributable to the project, and (2) the potential average annual benefit are presented. The expected average annual benefit reveals only the economic attributes of the project and assumes a return to pre-breach conditions only. The potential average annual benefits represents both the expected economic benefits and the potential benefits -- with a return to pre-breach conditions.

Both methods are concerned with the two principal economic species (scallops and quahogs) only. Other species of economic and biological importance are discussed in this report, but need further study to fully assess and update their ecological, economic and recreational values.

Data provided by the Broad Creek Committee are used to derive the first set of values (expected average annual benefit), and are based on records maintained by local (Nantucket) fishermen and the shellfish warden. According to the Tibbetts report (Addendum, Appendix 3), "These data apply to the harvest of shellfish in the Madaket Harbor area which the committee defines as including the waters from Madaket Harbor westward to the waters of adjacent Tuckernuck Island -- an area estimated to the some 2 to 2 1/2 times the area of Madaket Harbor as defined in the report." Data collected over twenty-one years (1953-1973) are provided in the report, of which 1953-1960 represents pre-breach data and 1962-1973 represents post-breach data. The 1961 data (breach year) are excluded.

TABLE 1

Expected Average Annual Benefit

Estimated average annual shellfish yields (commercial) for Madaket Harbor and projected benefits based on data provided by the Broad Creek Committee.

	Bushels Scallop	Bushels Quahog	Value Scallop1/	Value Quahog1/
Pre-breach	13,294	1,875	$199,410.00	$42,187.50
Post-breach	8,645	1,125	$129,675.00	$25,312.50
Difference (benefit)	4,649	750	$ 69,735.00	$16,875.00
			Total Difference (benefit)	$86,610.00

1/ Based on 1975 off-vessel prices of $15.00/bushel for scallops and $22.50/bushel for quahogs ($13.00/bushel cherry stones, $32.00/bushel little necks - average value $22.50).

A total average annual benefit of $86,610.00 (1975 values) for both scallops and quahogs is indicated. Additional increases for non-computed benefits such as reduced fishing effort (with comparable pre-breach yields), unexpected high yields or new fishing pressure, etc., are anticipated but require detailed analyses to fully assess the project benefits.

For determination of the "potential average annual benefit", it must be assumed that all 395 acres of Madaket Harbor covered by sand (with the breach) were productive and that comparable level productivity will be established once the breach is closed. Average annual shellfish benefits (bushels per acre) used in this analysis were provided by the Massachusetts Division of Marine Fisheries and are based on catch data taken from highly

productive areas of Massachusetts where shellfish production levels are better known.

TABLE 2

Potential Average Annual Benefit

Estimated average annual shellfish yields (commercial) for Madaket Harbor and projected benefits based on estimates for shellfish production (scallops, quahogs) determined by the Massachusetts Division of Marine Fisheries and applied to 395 acres (total area, unstable sand bottom described in the Tibbetts report).

Species	Average Annual Benefit1/ (bu/acre)	Average Annual Benefit2/ (total bu)	Average Annual Benefit (total $)
Bay Scallop	25	9,875	$148,125.00
Quahog	7	2,765	$ 62,212.50
TOTAL			$210,337.50

1/As determined by the Massachusetts Division of Marine Fisheries.

2/Based on 1975 off-vessel prices of $15.00/bushel for scallops and $22.50/bushel for quahogs ($13.00/bushel cherry stones, $32.00/bushel little necks - average value $22.50).

Since potential resources are involved, which may not develop or be fished to their full capacity, determination of initial fiscal benefits is not recommended. They do, however, provide an upper limit to the range of benefits possible under natural conditions with the project.

Regarding the determination of the project benefits it should be emphasized that the population dynamics of the scallop is extremely irregular and therefore difficult to predict. Furthermore, since the size of the area which will be recolonized is unknown, the determination of projected yields is even further subjected to complexity and variation. A favorable effect on both quahogs and scallops is anticipated, however, with closure of the breach.

Finally, since the breach in 1961, the marine alga Codium fragile has increased in abundance along the North Atlantic coast. Codium, when attached, can cause shellfish to be displaced by rough seas, sometimes resulting in large numbers of mortalities. What effect Codium will have

on projected shellfish populations in Madaket Harbor, with the project, is not known and should receive further study. It is not expected, however, that Codium will present a significant limiting factor to scallop and quahog populations.

With the project, some minor, temporary adverse environmental effects are anticipated. Dredging would create turbidity and siltation which may damage fish gills and destroy benthic fauna and habitat both in the harbor and adjoining areas. Some loss of established harbor bottom and accompanying fauna is also expected to result from direct removal by dredging. Furthermore, minor habitat loss is anticipated with construction (filling) of the dike. However, no long-term adverse environmental impacts are anticipated.

Minor adverse environmental effects (turbidity, siltation) which may affect fish and wildlife can be substantially reduced by the use of a hydraulic suction dredge instead of a dragline bucket dredge.

In summary, because of the highly transient shoreline in the area of the breach, the future of Madaket Harbor is not certain. While closure may naturally take place, the reduction of extensive shoal areas inside the harbor is not expected under natural conditions. Considerable destruction of fish and wildlife resources and habitat has resulted from the breach and consideration must be given to the prospect of their continued destruction, should the project not be implemented.

It is the Service's opinion that the project, as planned, will have a favorable impact on fish and wildlife resources. However, further evaluation of geological processes, both with and without the project, are required to fully assess the projects' environmental effects.

We understand that the project is currently being planned under Principles and Standards and request that a copy of your Survey Report, when completed, be forwarded to this office for our review.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Post Office and Courthouse Building
BOSTON, MASSACHUSETTS 02109

JAN 23 19[illegible]

Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Sir:

This is a supplement to our letter of comment, dated December 6, 1974, regarding the preliminary report prepared by Tibbetts Engineering Corporation on navigation, flood control, hurricane protection, and related improvements for Madaket Harbor, Nantucket Island (Nantucket County), Massachusetts.

This study is authorized by Section 219 of the Flood Control Act (Title II, Public Law 90-483), approved August 13, 1968. The report has been prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

As a result of our review and comments on the preliminary report, "Feasibility Report, Madaket Harbor, Nantucket, Massachusetts, Water Resources Improvement Study, 1 October 1974, Vols. 1 of 2 and 2 of 2", additional information has been requested by Mr. Arpin's telephone call to our Concord, New Hampshire, Area Office on December 27, 1974. Specifically, we have been requested to provide additional information regarding our support for the project and its proposed benefits, and our evaluation of hypothetical shellfish benefits projected by Dr. Matthiessen.

Based on the material presented thus far, this Service does not object to the project as planned. We believe that increased shellfish harvest and recreational benefits are attainable, with minor adverse environmental effects. In order to accurately estimate anticipated benefits, however, the following additional information (and/or clarification) is required.

Our letter of December 6, Comment 3, discussed the need for a clear and detailed explanation of the total annual benefits. For example,

since no other values are given, we must assume that the benefits (Appendix 1, No. F-1) are based on the predicted theoretical yield, as presented in the Summary (Appendix 3, Page 15, Paragraph 2). With regard to these theoretical yield predictions, it is questionable as to whether "20,000 bushels per year for oysters and hard clams" implies 20,000 bushels total or 20,000 bushels for each of the shellfish types discussed.

In addition, we offer the following comments which, in our opinion, have either been inadequately considered or inadequately discussed:

1. Projected values appear to be based on optimum production levels. These levels are not generally anticipated year after year with mariculture programs.

2. The theoretical yields projected by Dr. Matthiessen assume favorable, natural reproduction and negligible losses from predation and other causes; these factors should be considered in making yield predictions.

3. The report apparently fails to take into account the high variability of scallop populations.

4. The report apparently fails to take into account the effect on hard clams and scallops of increased competition with the addition of the oyster culture program.

5. The oyster culture program in Madaket Harbor is untested, and results are considered to be speculative. Therefore, to include such benefits, based on optimum production figures, does not seem feasible at this time.

6. In determining the proposed benefits, it appears that the cost of the mariculture program has not been taken into account. Such a program, if intensively managed (as would be required to obtain the theoretical yields), would be expensive to initiate and maintain, and would, thereby, reduce the proposed annual monetary benefits. We believe that additional information (local interests, funding, details of local management, details on the availability of seed stocks, etc.) is necessary.

We acknowledge the difficulty in making shellfish harvest projections, considering the paucity of applicable data on mariculture, the high degree of variability naturally associated with shellfish populations, and the complexities of extrapolating data on these highly variable populations. It is our opinion that while Dr. Matthiessen's hypothetical benefits may be obtained, his methods and results are subject to a significant degree of variation and should be so indicated. Projected yields should also be modified to allow for these variations.

Regarding Dr. Matthiessen's methods of determining projected harvests, we question the validity of "substituting bay scallops for oysters" (Appendix 3, Pages 7 - 9) for making productivity determinations. In our opinion, this approach needs further explanation and documentation.

In view of these considerations, we believe that the projected benefits are too high. In order to test the accuracy of the proposed benefits, we suggest that comparisions be made by utilizing figures (if available) from well-studied, comparable areas. Again, we suggest that an attempt be made to determine the validity and accuracy of the Broad Creek Committee's statistics (Appendix 3 - Addendum) and, if feasible, they be compared in detail to Dr. Matthiessen's projected benefits.

We hope that we have adequately answered your inquiry regarding our support for the project and our evaluation of Dr. Matthiessen's hypothetical benefits. If we can be of further assistance regarding this project, please let us know.

Sincerely yours,

Regional Director

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Post Office and Courthouse Building
BOSTON, MASSACHUSETTS 02109

DEC 6 197[illegible]

Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

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As a result of our review of the preliminary report, "Feasibility Report, Madaket Harbor, Nantucket, Massachusetts, Water Resources Improvement Study, 1 October 1974, Vols. 1 of 2 and 2 of 2", we submit the following comments for your consideration.

1. It is the impression of the U. S. Fish and Wildlife Service and the Department of the Interior that projected values for shellfish harvests (Appendix 1, No. F-1) are based entirely on hypothetical evaluations, made by Dr. G. C. Matthiessen (Appendix 3), with due consideration of harbor area. These evaluations involve complex and highly variable biological, physical, and chemical parameters. As a result, projected values are also subject to high levels of variance and should be so indicated.

2. A careful analysis of the shellfish harvest data submitted in the Broad Creek Committee's "Madaket Harbor Study" should be made to determine its accuracy and validity. If useable, a comparison of these data and Dr. Matthiessen's is in order.

Projected values for scallops and quahogs could then be made with reference to pre-breach harvest values.

3. A clear and detailed explanation of methods employed to determine the total annual benefits (Appendix 1, No. F-1) is necessary. We believe that Appendix 1, F-2, "Method of Analysis" is not adequate. Regarding this section, the following questions need to be answered:

   (a) How were total annual benefits determined?

   (b) Are these values based entirely on average optimum values?

   (c) Has consideration been given to the high variability of scallop populations in making harvest predictions?

   (d) Do projected oyster harvests take into account the effect of increased competition on quahogs and scallops?

4. Appendix 1, F-2, "Method of Analysis" states that "an evaluation of existing harbor shellfish species of commercial value was made." We cannot agree with that statement. The sample program, involving one day of sampling in spring and two days of sampling in late summer, is not adequate to evaluate existing commercial shellfish species. Descriptions such as "few" and "numerous" have little or no significance with respect to shellfish numbers when undefined.

5. Benthic samples and observations made by Marine Research, Inc., suggest a correlation between increased scallop numbers and increased eelgrass or bottom stability. They neither indicate population size, nor can they be used to determine potential productivity of shellfish resources in Madaket Harbor.

6. Projected values for the oyster mariculture program are, in our opinion, highly speculative and should be considered as such if retained. Without additional studies and experiments such as those suggested by Dr. Matthiessen, Appendix 3, or additional information, we believe that these values should be omitted from the expected total annual benefits.

7. Additional information regarding the beach stabilization program, including proposed design, suggested regulation (including vehicle traffic to Esther Island), and project dimensions would be helpful in further determining anticipated environmental impacts of the project.

We appreciate the opportunity to comment on this report and look forward to working with you as this study progresses.

Sincerely yours,

Robert Stanley

ACTING Regional Director

MARINE RESEARCH, INC.

141 FALMOUTH HEIGHTS ROAD
FALMOUTH MASS 02540

February 24, 1975

Mr. Richard Silviera
Tibbetts Engineering Corporation
620 Belleville Avenue
New Bedford, Massachusetts 02745

Dear Dick:

I have had an opportunity to review the comments contained in a letter dated 23 January, 1975, from the Department of the Interior, Fish and Wildlife Service, to the Corps of Engineers, relating to the proposed improvements for Madaket Harbor, Nantucket. I would like to respond specifically to the questions raised in this letter regarding the report prepared by Marine Research, Inc., dated 13 September, 1974, and submitted to you in fulfillment of our contract. The following statements, designated by number, correspond with those questions similarly designated in the letter referred to:

1) The theoretical yield of 20,000 bushels per year is total for the 300-acre area immediately under consideration, i.e., 20,000 bushels of oysters or 20,000 bushels of clams, (or 10,000 gallons of bay scallop meats). In considering the entire area of Madaket Harbor - approximately 750 acres - these theoretical yields might conceivably be doubled. However, we wish to re-emphasize that such yields are seldom obtained on a consistent basis, and it is for this reason that we have urged that culture experiments be undertaken in Madaket on a limited and trial basis prior to initiation of expensive improvements the outcome of which is uncertain.

2) We have offered "optimum", or theoretically optimum, production levels because, in our opinion, an average sustained level of production in an untried area is virtually impossible to define. We have also stated - Page 10, lines 5-9 - our doubts as to whether even an intensively managed fishery would produce these yields on a sustained basis.

3) Intensity of natural production and natural mortality rates are impossible to predict. Again, we refer to Page 10, lines 5-9.

4) Recognition of the variability in scallop populations is indicated in Page 6 (bottom line) and Page 9 (lines 5-9).

5) All estimates have been based upon the culture of a single species, i.e., monoculture. The factor of competition has been recognized in Page 8, lines 5-9.

6) We have promised no benefits from the culture program. Rather, we have proposed a pilot program to determine whether or not benefits may realistically be anticipated. Again, please refer to Page 10, lines 5-9.

7) For these reasons, we have proposed a pilot program. Please refer to (5), Page 12, ("evaluation of program").

8) If we did not recognize the "significant degree of variation" alluded to, we would not have suggested a pilot program. Please refer to Page 6, bottom paragraph, and Page 7, top paragraph.

9) Please refer to Page 9, lines 10-12. (We know of no other documentation in the literature.)

10) We wish to re-emphasize that we have projected no benefits. Rather, we have given production figures based largely upon theoretical calculations and upon specific culture operations in other areas. Average production figures over sustained periods of time in managed areas ecologically similar to Madaket are, to our knowledge, unavaiable.

We cannot state too strongly our belief that to recommend undertaking the proposed improvements to Madaket Harbor on the strength of the theoretical shellfish production figures described in our report would be a misconstrual of the intent of our report. We clearly recognize many, if not all, the hazards and uncertainties in shellfish culture. We certainly do not recommend that the proposed improvements be undertaken without prior culture experimentation in this area, if the primary justification of the improvements are the presumed rewards from shellfish culture.

Sincerely yours,

MARINE RESEARCH, INC.

G. C. Matthiessen

GCM:jba

Study and Report on Closing
Breach in Barrier Beach, Madaket Harbor
Nantucket, Massachusetts
Contract No. DACW 33-73-C-0072
Prepared for the
Department of the Army
U.S. Corps of Engineers
New England Division
by
Tibbetts Engineering Corp.
620 Belleville Avenue
New Bedford, Mass.
Job No. 2822000
June 20, 1973

APPENDIX A

Study and Report on Closing
Breach in Barrier Beach,
Madaket Harbor, Nantucket,
Massachusetts
Contract No. DACW 33-73-C-
0072

APPENDIX A

DESIGN CRITERIA FOR PROPOSED PLAN OF IMPROVEMENT NANTUCKET-ESTHER ISLAND CHANNEL

1. GENERAL

The proposed plan of improvement is designed to fill in the channel between Nantucket Island and Esther Island in order to prevent littoral drift from the south shore of these islands through the channel into Madaket Harbor. Under this plan, the channel would be closed by a reinforced sand barrier. The resulting dune structure should be designed to withstand the most severe storm of record in the vicinity, which is Hurricane Carol of August 31, 1954.

The dune profile would consist essentially of two sloping beaches which rise from the sand fill on either side of a core reinforcement to meet with a wide horizontal crest. With Hurricane Carol as a design storm, certain beach slopes and a minimum crest height may then be

specified for protection. As will be shown here, the crest should be sixteen feet above mean low water, and the beach slope on the south side should be 1:15 or less to prevent overtopping. The slope on the north side can be steeper, e.g., 1:5, because wave action will be less severe.

However, due to the fact that at the present time the land elevation each side of the breach is approximately 11 0 feet, and therefore subject to some overtopping, a more practical design consists of a dune crest at elevation 11.0 feet above mean low water and beach slopes of 1:15.

2. HURRICANE CAROL OF AUGUST 31, 1954

This storm caused the highest recorded still-water levels in the vicinity of Nantucket Island. No data is available for Esther Island, but highwater levels from seven (7) to eight (8) feet above mean sea level were compiled for several points on the north side of Nantucket, e.g., Great Point. Since those areas lay in the lee of

the storm, it is expected that the water levels at Esther Island were even higher. Accordingly, a calculation of storm surge for Esther Island is given in this appendix.

Based upon data compiled by Reid (Beach Erosion Board Technical Memorandum No. 83) the following parameters are adopted as a simulation of the design storm: (simulating Hurricane Carol)

Fetch: F = 100 miles
Maximum Winds: W = 95 mph
Wind Direction: Variable, from south to southwest

All calculations which follow will be based upon these design parameters:

3. WIND SETUP

The total storm surge is assumed to be a superposition of three (3) contributions: (1) wind setup; (2) barometric rise; and (3) astronomical tide. The wind setup should be a large contribution, since winds from the south toward Esther Island act over many miles of shallow continental shelf waters.

Figure A-1 shows bottom profiles for distances up to two hundred and fifty miles from the island, and Figure A-2 shows near field bottom profiles at distances less than ten miles. These profiles are sufficiently irregular that the usual "constant shelf slope" formula for setup would be a very crude approximation. For more accuracy the shelf is broken up into smaller sections and the total setup computed as a summation of incremental contributions, as follows:

$$S = \sum_i \frac{KW^2 \propto x}{g\,(\propto h - \propto S)} \ln\left[1 + \frac{\propto h - \propto S}{h + S_i}\right] \qquad \text{(A-1)}$$

where K = dimensionless wind drag coefficient = 3.3×10^{-6}

h = average depth in the segment (ft)

S_i = average accumulated setup in the segment (ft)

$\propto h$ = decrease in depth over the segment (ft)

$\propto S$ = incremental setup over the segment (ft)

$\propto x$ = total length of the segment (ft)

g = gravitational constant (32.2 ft/sec^2)

W = local wind velocity in the segment (ft/sec)

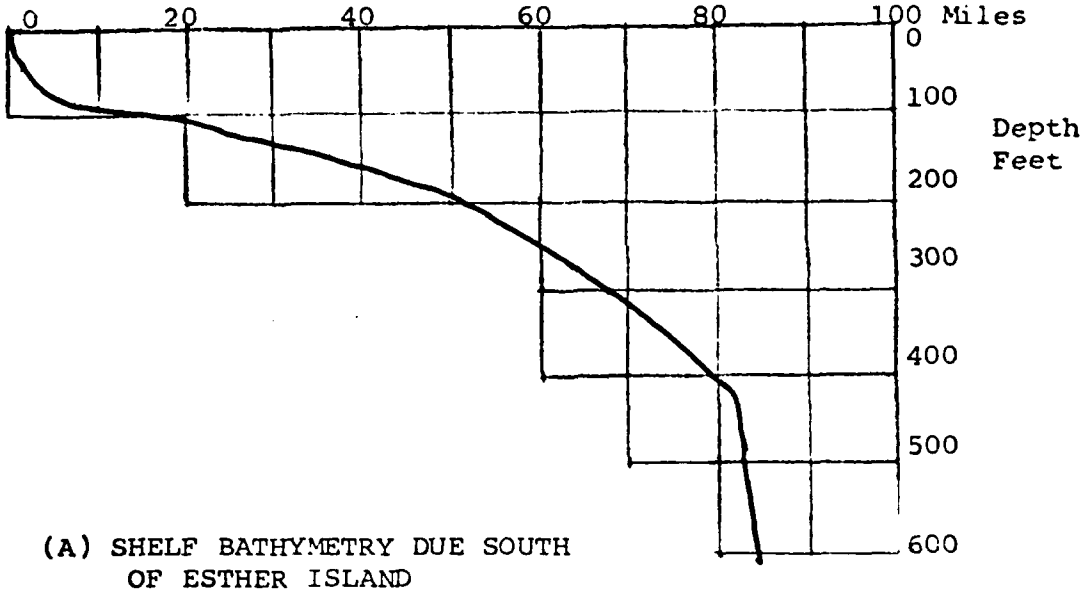
Equation (A-1) was evaluated for the design storm for both the south and southwest bottom profiles from Figures A-1 and A-2. The results, for W=95 mph (139.3 ft/sec) and a fetch of 100 miles, are:

(a) South Profile: S = 7.0 ft

(b) Southwest Profile: S = 7.8 ft.

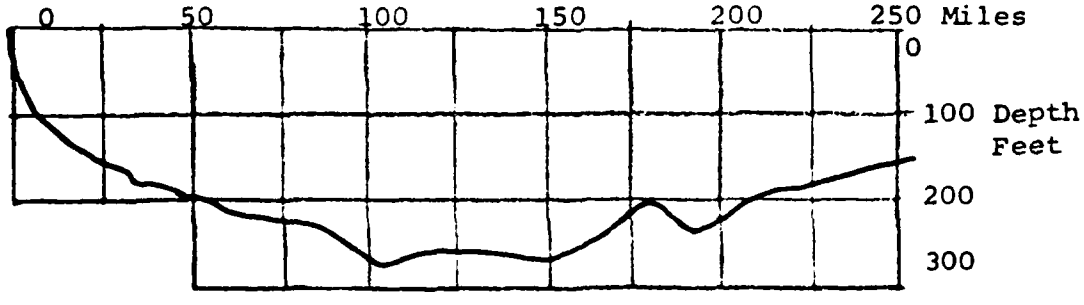
Thus, a storm wind from the southwest is a more critical condition.

DISTANCE FROM ESTHER ISLAND



(A) SHELF BATHYMETRY DUE SOUTH OF ESTHER ISLAND

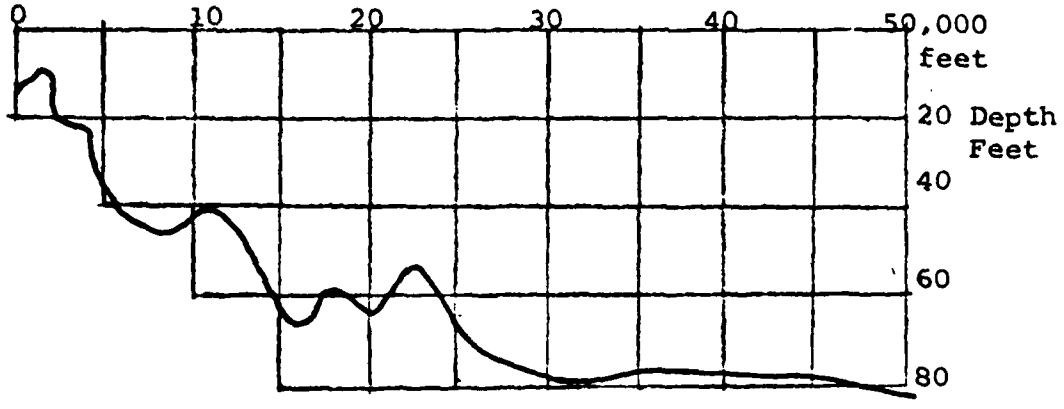
DISTANCE FROM ESTHER ISLAND



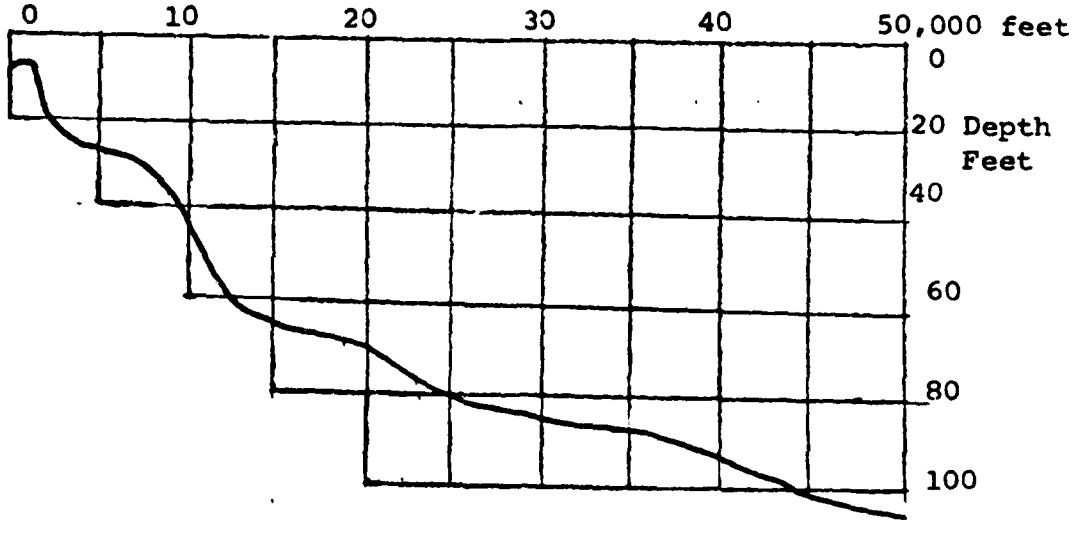
(B) SHELF BATHYMETRY DUE SOUTHWEST OF ESTHER ISLAND

Figure A-1. Continental Shelf Profiles Approaching Esther Island

DISTANCE FROM ESTHER ISLAND



(A) NEAR FIELD BATHYMETRY DUE SOUTH OF ESTHER ISLAND



(B) NEAR FIELD BATHYMETRY DUE SOUTHWEST OF ESTHER ISLAND

Figure A-2. DEPTH PROFILES VERY NEAR ESTHER ISLAND

4. BAROMETRIC WATER RISE

The barometric water rise is estimated from Equation 1-62, page 138, of CERC Technical Report No. 4, Shore Protection Planning and Design:

$$S_b = 1.14 (P_n - P_o) \left[1 - e^{-R/r}\right] \qquad (A\text{-}2)$$

where P_n = normal atmospheric pressure (in.Hg.)

P_o = pressure at the center of the storm(in. Hg.)

R = radius of maximum storm winds

r = radius to the point of interest

The factor 1.14 converts inches of mercury to feet of water (S_b). The maximum barometric rise is at the center of the storm (r=o), but winds are not critical under these conditions. The proper design condition for total surge is $r \cong R$ where maximum winds prevail, and hence $e^{-R/r} = 0.3$. Normal pressure is $P_n = 29.92$ in. Hg. and P_o in Hurricane Carol was 28.35 in. Hg. The design barometric rise is thus:

$$S_b = 1.14 \quad (29.92 - 28.35) \left[1 - 0.3\right] = 1.2 \text{ ft.}$$

5. ASTRONOMICAL TIDE

The U. S. Department of Commerce Tide Tables list ten stations in the vicinity of Esther Island, most of which are on the north side of Nantucket Island, where tides are higher. Three points are listed which approximate the south side of Esther Island:

AREA	MEAN TIDE (ft)	SPRING TIDE (ft)
Smith Points, North Side	1.5	1.9
Miacomet Rip	1.7	2.0
Tom Nevers Head	1.2	1.4

As a design point, we adopt the following maximum tidal range: Esther Island: $S_a = 2.0$ ft.

6. TOTAL STORM SURGE FOR DESIGN STORM

A fourth contribution to storm surge is the so-called Coriolis or "bathstrophic" storm tide (Freeman, et al, J. Marine Research, 16 (1), 1957), due to wind components parallel to the coast. This component is neglected here, because the more critical surge occurs when the winds are directed normal to the coast. Therefore, the total calculated design surge is given in Table A-1.

TABLE A-1. DESIGN STORM SURGE AT ESTHER ISLAND

Item	South Winds	Southwest Winds
Wind Setup	7.0	7.8
Barometric Rise	1.2	1.2
Astronomical Tide	2.0	2.0
TOTAL SURGE ABOVE MEAN WATER LEVEL:	10.2 ft.	11.0 ft.

The critical condition is thus 11.0 feet for winds from the southwest. This value is exclusive of runup from wind-waves created by the storm. The wind-waves and associated runup will be computed in the following sections.

7. WIND WAVES

Before estimating wave runup on the proposed dune structure in the Esther Island channel, wind-wave and retraction calculations should be made to estimate the height and period of waves approaching the island.

For storm winds of sufficient duration in shallow shelf waters, maximum wave heights may be calculated from Figures 1-29 through 1-32 of CERC Technical Report No. 4, after which wave lengths and periods can be calculated from Figure 1-28. These calculations were made for southwest

winds, for which the surge is higher as shown above.

The results are summarized in Table A-2.

TABLE A-2

Wind Velocity from Southwest (mph)	Significant Wave Height (ft)	Significant Wave Length (ft)	Significant Wave Period (sec)
50	16	260	7.2
60	20	300	7.7
70	24	380	8.6
80	28	460	9.5
95	34	510	10.1

Thus the shelf waters are sufficiently deep that extremely large waves can be generated by a storm. Since the waters very near Esther Island are only about 14 feet deep, even with the storm surge included, it follows that the highest waves would break from one to two miles out from the island, causing negligible runup. Only the smaller, shorter waves would break directly upon the island. We adopt the following conditions as design parameters for runup on the proposed structure:

DESIGN BREAKING WAVE AT ESTHER ISLAND CHANNEL:

(a) Wave Height: 11 feet
(b) Wave Length: 200 feet
(c) Wave Period: 7 seconds

8. WAVE REFRACTION

As a further check upon estimated wave action at Esther Island, one should construct refraction diagrams for various periods and directions to determine if storm waves are increased or attenuated by the local topography of the island. These diagrams are computed either numerically or graphically from the procedures outlined in Section 1.261 of CERC Technical Report No. 4. A typical refraction diagram for Esther Island is shown in Figure A-3 for eight second waves approaching from the southwest. Calculations indicate no appreciable difference between seven second and eight second waves from the critical southwest direction. It is seen that Esther Island, far from being a sheltered area, actually causes the wave orthogonals to converge sharply, indicating intense wave activity during storms approaching from the southwest. We conclude that no reduction should be made in the design breaking wave conditions determined in Section 7 above.

9. WAVE RUNUP

Wave runup calculations depend upon the incident wave properties and the shape of the beach structure and are outlined in Section 3.271 of CERC Technical Report No. 4.

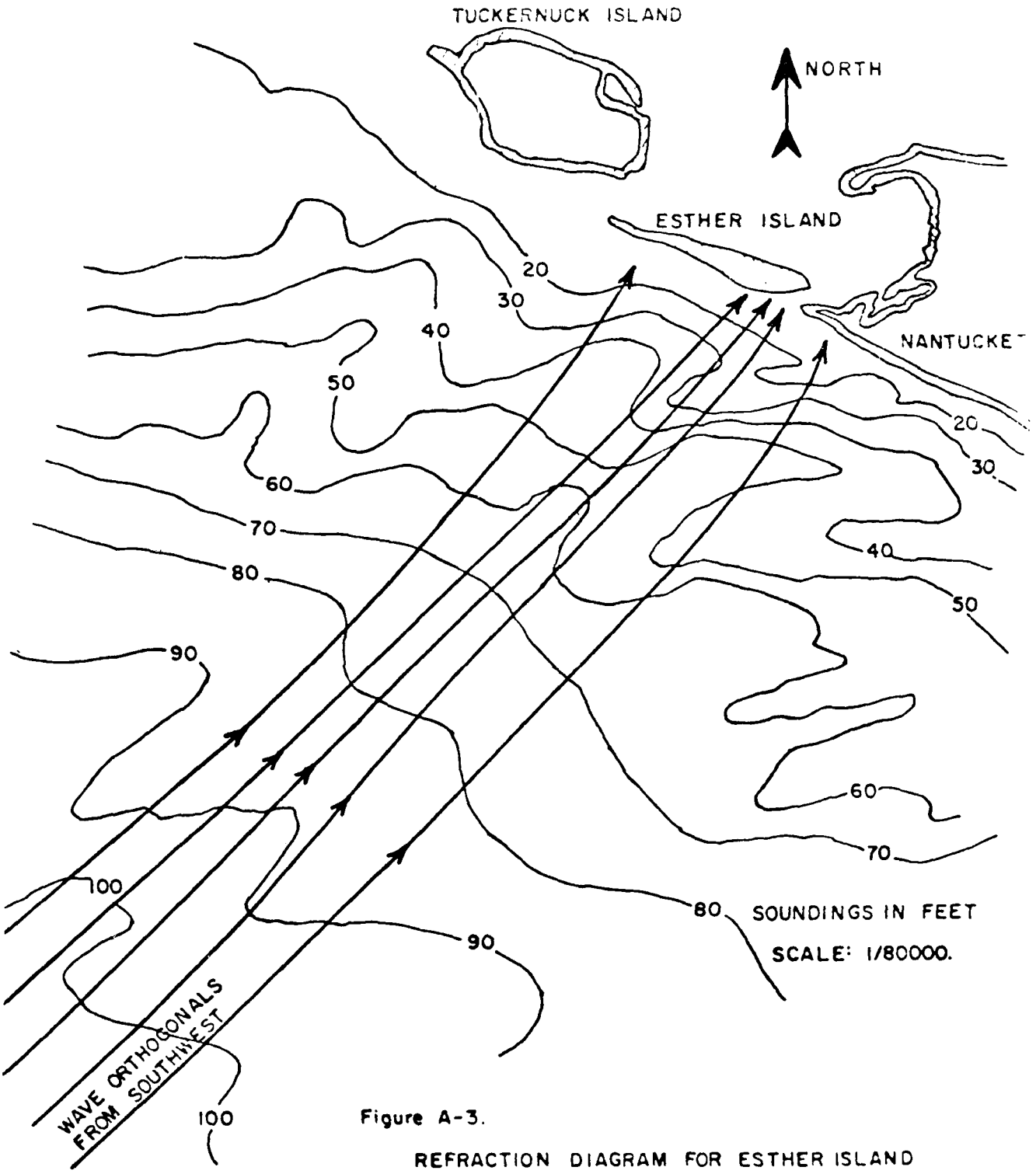


Figure A-3.

REFRACTION DIAGRAM FOR ESTHER ISLAND
FOR WAVES OF EIGHT SECOND PERIOD
APPROACHING FROM THE SOUTHWEST.

The characteristics of the design wave are as follows:

H_b = 11 ft.

d_b = 14 ft.

H_o' = 9 ft.

T = 7 Sec.

d_b/H_o' = 1.6

T^2/H_o' = 0.18

The value of d_b/H_o' indicates that Figure 3-2 of Report No. 4 should be used, after which, corrections for model scale effects can be made from Figure 3-11.

The proposed structure would be a broad sloping dune built up on either side of a core reinforcement across the channel and including a horizontal crest which precludes wave overtopping. ~~This proposal~~ is shown in Exhibit "F".

The toes of the sand slopes should be placed at a distance just sufficient to avoid overtopping of the crest, thereby minimizing the amount of sand needed to fill in the channel.

Similarly, the crest should be the minimum height required. The run-up calculation depends upon the wave parameter $H_O'/T^2 = 0.18$ and the dune slope $L_1/(R + 11.0)$, where R is the run-up in feet and 11.0 is the maximum surge height from Section 6 of this appendix.

Assuming various values of the dune horizontal width L_1 on the ocean side of the channel, the run-up R may be guessed and calculated iteratively from Figure 3-2 of TR No. 4. The value of R must then be increased by the scale correction in Figure 3-11, which varies from 3 to 30 percent. The final calculations for corrected run-up are given in Table A-3.

TABLE A-3

RUN-UP CALCULATIONS FOR WAVES
BREAKING AT THE TOE OF THE
PROPOSED DUNE STRUCTURE (Figure A-3)

Berm Width L_1 (ft)	Run-up, R (corrected - ft)	Dune Slope	Minimum Crest Height - ft
50	25.8	1/1.5	36.9
100	11..	1/5	22.3
150	5.1	1/9	16.1
→ 175	4.3	1/12	15.3

(continued)

TABLE A-3 (continued)

Berm Width L_1 (ft)	Run-up, R (Corrected - ft)	Dune Slope	Minimum Crest Height - ft
(from previous page)			
200	3.3	1/14	14.3
250	2.8	1/18	13.8

A suitable design condition is indicated by the arrow in the table. We may round these figures off to a final design value for the proposed structure as given in Table A-4.

TABLE A-4

DESIGN STRUCTURE TO WITHSTAND
HURRICANE CONDITIONS AT ESTHER ISLAND

Crest Height Above Mean Low Water	16 feet
Crest Width	50 feet
Dune Slope, Ocean Side	1/15
Total Dune Width	410 feet
Horizontal Berm Width, L_1 , L_2	180 feet

Here we have assumed two equal berms of 180 ft width on either side of the crest, although in fact, the berm on the Madaket Harbor side may be steeper (1/10 or even 1/5), since wave action and run-up will be very small on that side, which is in the lee of the storm.

10. RECOMMENDED DESIGN OF DUNE STRUCTURE

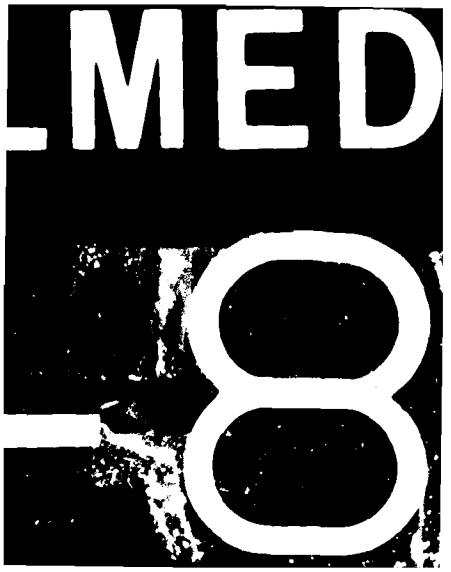
Information given in Plates B-4 of the Narragansett Bay Hurricane Survey interim report of 1957 by the Corps of Engineers shows that tidal flood elevations caused by Hurricane Carol have less than a 2 percent chance of occurring in a given year. If the dune structure is constructed to elevation 16.0 feet above MLW overtopping is therefore essentially precluded.

However, due to the fact that elevations on each side of the breech are approximately 11.0 feet above MLW, it is apparent that flooding and overtopping may occur on both sides of the breech closing.

According to the Narragansett Bay report, a storm

exceeding 11.0 feet elevation can be expected about 5 percent of the time.

For practical reasons, therefore, the recommended crest elevation for the dune structure is selected at elevation 11.0 feet above MLW. Overtopping can be expected about once every 20 years with attendant sand erosion. Savings can be affected by reducing both the ocean and harbor side slopes to a minimum since in general the flatter the slope the less the wave run-up. For instance, a dune slope of 1:12 would require a minimum crest elevation of 15.3 ft while that of 1:20 an elevation of 13.6 ft. A flatter slope on the harbor side is required to counteract possible erosion due to wave overtopping. Again, for practical reasons, a dune slope of 1:15 is selected for both the ocean and harbor sides of the dune structure.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